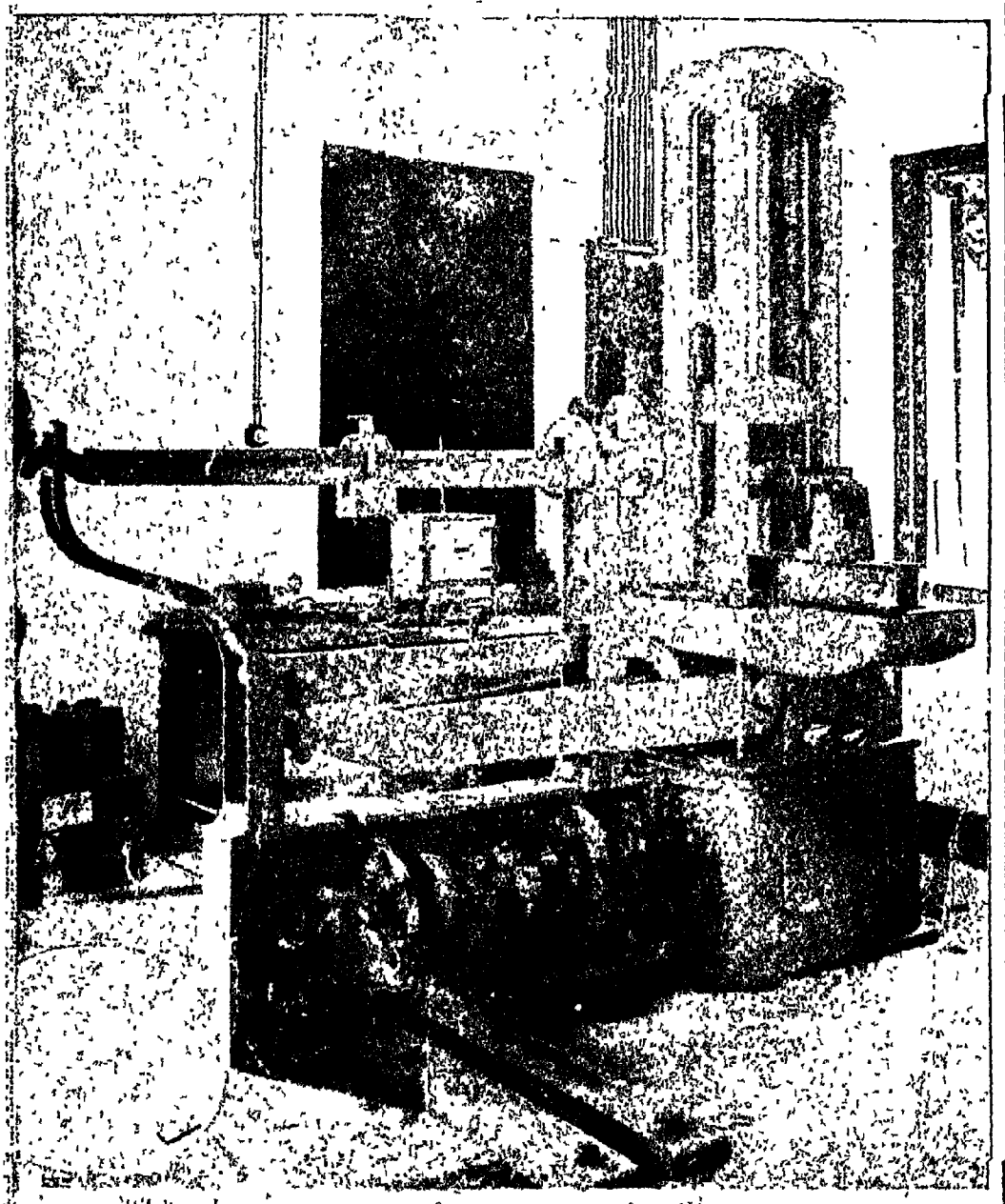
FOREST RESEARCH IN INDIA

1920-1921



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Progress Report of Forest Research Work in India

For the Year 1920-21

(*July 1st, 1920—March 31st, 1921*)

Including the Administration Report of the Forest Research Institute, Dehra Dun



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Photo - Mech. Dept., Thomason College, Roorkee. Photo by H.R. Blanford.

Successful Teak Regeneration in Burma.
Planted in 1920, 6′ × 6′. Photo. taken 28th June 1921, immediately after weeding.

INTRODUCTION.

In the second year of its existence in this form the report has increased in bulk but its faults have at the same time become more apparent. It is obvious that in future issues the mass of information collected must be arranged according to some system and that parallel investigations in different provinces should be correlated.

It is hoped to find time for the discussion of this question at the Silvicultural and Utilisation Conferences which are being held in the present year and that an arrangement will be come to as to the form to be adopted by Provinces in compiling their reports. As examples of possible arrangements attention is drawn in this issue to the silviculture reports of the United Provinces and Burma.

It is also recognised that in future an index will become a necessity and if possible it will be arranged for in the next report.

It will be noted that owing to the change in the forest year the report covers a period of only nine months, namely, July 1920—March 1921.

It is regretted that in some chapters certain provinces have had to be omitted altogether as their reports were either not received at all or, as in the case of Coorg, were received too late for insertion.

Progress of Forest Research in India 1920-21

CHAPTER I.

General.

The development of forest research and its organisation in India has progressed considerably in the period under review.

The preliminaries to the enlargement of the Research Institute at Dehra Dun are now well in hand. The land has been acquired for the purpose and it is hoped that building operations will be commenced in a few months.

The first buildings to be undertaken are the workshops for the Economic Branch which will include a sawmill and wood workshop, a timber testing workshop, seasoning kilns and a pulp and paper plant with the necessary offices and store godown. Most of the machinery required is already in India.

The following information is communicated by Burma:—

"The project for the building of a Forest Research Institute at Maymyo is unfortunately not much further advanced now than it was a year ago. Drastic curtailment of the Public Works Department Budget for 1921-22 meant that the project had to be cut out altogether and it still remains to be seen whether anything will be done before the latter part of 1922.

Lack of suitable buildings, bad as it is, does not mean that nothing has been done. Mr. H. R. Blanford, O.B.E., returned from leave at the end of December 1920, and was gazetted as provincial Silviculturist. Mr. Blanford's report speaks volumes for his grasp of and enthusiasm for his subject.

It is very much to be regretted that the year has closed without a special officer being appointed to study the bee-hole borer. This pest is far and away the most serious one that has hitherto come to notice either in India or Burma.

Plans for the experimental workshop and laboratory at Rangoon are gradually being evolved. The dry kilns are under construction."

CHAPTER II.

Silviculture and Working Plans.

Central Institute.

During the year no new sample plots have been laid out by the Central Institute but 34 plots have been remeasured and 17 experimental plots visited. There was a large amount of remeasurement due but as the greater part of this was taken over by the United Provinces Silviculturist it left the Central Silviculturist free to visit various provinces and assist in the formulation of their future research policies.

The Silviculturist spent 102 days on tour, visiting Kurseong, Darjeeling, and the Sundarbans in Bengal; Haldwani and Dehra Dun Forests in the United Provinces; and various parts of Burma. The principal work has been the discussion of the future research policies for these provinces with explanations of the Dehra system of recording results and compiling statistics, which it is difficult if not impossible to explain by correspondence. This has been the most important and it is hoped the most productive work during the year.

In accordance with the decentralisation policy 119 sample plots have been handed over to provincial silviculturists, with complete copies of results to date—the originals being retained at the Central Institute. These comprise 40 plots to Bengal, 13 to Madras and 66 to the United Provinces. Further plots will be handed over early in the coming year.

The following actual experiments may be mentioned and reference is invited to last year's report in connection with several of them:—

(*a*) The Thano clear felling of sal has been badly damaged by frost. It is now evident, however, that a large number of the plants have not been killed but it is too early to express any opinion as to the success or otherwise of the method.

(*b*) The experiment in storing sal seed was hampered by the fact that the rains were exceptionally unfavourable. Up to date there are good grounds for believing that this problem may be solved, and in any case experiments on a much larger scale will be undertaken in the coming year.

(*c*) Regarding the Zaberkhet experiments, again the almost entire failure of winter rains has made conditions more than usually unfavourable. The winter *Dalbergia Sissoo* sowings, the bamboo seedlings, and the sowings of *Butea*



Photo.-Mech. Dept., Thomason College, Roorkee. Photo. by L. Teague.

Kimbu (*Morus lævigata*) one year in the Nursery and 14 months planted out in the Taungya after root and shoot pruning.

frondosa have failed entirely—the last owing to damage by porcupines. These experiments will not be repeated. The chir sowings, unweeded and untended, are at present very promising and will be extended during the coming year. As few nursery plants were ready the winter root and shoot cuttings of Sissoo were almost entirely composed of plants dug from the Song river bed and were therefore not favourable for experiment. They were out of the ground many hours and had to be transported many miles, they were not ideal in size, were badly grazed and were transplanted to an entirely different type of soil and lastly the winter rain failed almost completely. Despite this a large number are throwing out shoots and more will do so. Of 250 odd plants obtained from a local nursery almost every plant has sent up a shoot. The experiment will be continued this year with nursery plants, which are now available, and though definite conclusions cannot yet be drawn there is every reason to believe that this method is an easy way of solving the regeneration of the blanks without any attention during the rains.

(*d*) The Camphor experiments have yielded complete enough results to render a tentative publication possible in the near future.

(*e*) A taungya experiment of 10 acres in Thano has been commenced.

The photographic branch now contains 3,736 photographs and 3,568 negatives. No additions have been made to the lantern slides and colour transparencies.

A Note on Afforestation of Ravine Lands in the Etawah District, United Provinces, by Mr. E. A. Smythies appeared as a Forest Record.

Owing to press difficulties no other publications have appeared during the year but the following have issued since the close of the year:—

(1) Note on the weights of seeds.

(2) Note on the rate of growth of Bengal Sal.

(3) A code for the collection and tabulation of statistical data.

(4) An article on Sal taper curves, in collaboration with Mr. E. A. Smythies. (*Indian Forester*, April 1921).

(5) Notes on Artificial Regeneration in Bengal, by Messrs. E. O. Shebbeare, A. K. Glasson, I.F.S., Teague and P. T. Russell.

(6) Note on the Miscellaneous Forests of the Kumaon Bhabar, by Mr. E. A. Smythies.

The arrears mentioned in last year's report have been cleared off so far as the actual routine work is concerned, but during the whole year the branch has suffered considerably from shortage in the assistants' staff and office. The ledger files are becoming a mass of undigested knowledge very sadly in need of arrangement.

What is much more serious is that the shortage of staff has caused great neglect of the programme. It is true that experimental silviculture cannot be done as well from the Central Institute as in the Provinces themselves and the need for decentralisation is admitted, but there will always be certain experiments to be conducted at Dehra if the branch is to remain a living entity, and moreover decentralisation, though agreed to, is not by any means complete. Except in four provinces the progress of silvicultural knowledge for all India depends largely on the Central Institute.

United Provinces.

The work carried out in the Silviculture Division has followed as closely as possible the printed programme of research for the Working Plans and Silvicultural Research Circle. The shortage of staff in the province has however resulted in the Silviculturist's having to hold charge of the Haldwani Division in addition to his own duties from the commencement of the working season, so that it was impossible to deal with problems which could not be studied near Haldwani—in fact, except for the measurement of a few sample plots near Dehra Dun, and the work done on two flying visits to the Kumaun Hills, nothing could be done elsewhere.

The several heads of the research programme mentioned are followed as far as convenient in the following report:—

I. Sal:—*Natural Regeneration.*—A series of large scale experiments from which it is hoped to get important results, has been initiated in Haldwani Division, in Lakhmanmandi, Compartment 4. This is a good quality Bhabar sal forest which has been placed in Periodic Block 1 of the Conversion Working Circle, and which already contains abundant small regeneration believed to date mostly from the 1913 seed year; this regeneration has been dying back annually in the usual fashion, after attaining a height of 1—2 feet. Four plots each of 25 acres were laid out; in the first, a clear felling of sal was made, and the small admixture of miscellaneous species left to form a light soil cover; the area was naturally subjected to a maximum of trampling, etc., during conversion and extraction, and it was burnt over on 11th and 15th February 1921, to remove the smaller débris. The second plot was felled over to remove all the lower canopy, leaving only a high and open cover of mature sal trees: this also was burnt over as soon as conversion was completed, on 25th March 1921. In the fourth plot nothing was done except to burn it over on 26th March. The third plot was made as a control

and nothing was done. A fifth plot of the same size has been demarcated, and will be dealt with under Mr. Hole's strip system, markings being made in August, 1921, under the Forest Botanist's personal directions. Small observation plots 15 feet square have been laid out in each area for the record of the history of individual seedlings, each of the latter being mapped, measured and described. It is to be emphasised that this research is directed towards a study of the conditions of development of a seedling crop already on the ground, and not a study of requirements for getting such a crop. It may also be noted that, in the Conversion Working Circle of the Haldwani Division, the real problem is this one of getting up a new crop from existing seedlings, as these are abundant almost everywhere.

Two similar experiments in clear felling and shelterwood felling were also carried out in Dehra Dun Division, at Lachiwala, in quality II, sal forest, and above the Hathiwala line at Timli, in a quality IV crop. The object is to see the development of the new crop obtained from seedling and suppressed advance growth under these conditions of felling with burning of the slash. Each area is ten acres in extent. Control plots, in which the growth of seedlings of known age under these conditions can be examined, have also been laid out by Mr. Hole. The shoots in the area at Lachiwala are already (July) 7 feet high. In this area the actual seasons of growth are also being observed.

The data obtained to date from the small sal regeneration plots laid out all over the province after the 1913 seed year have been collated, but nothing conclusive can be deduced from them beyond the fact that during the 7 years which have elapsed, the seedling plants have all failed to commence vigorous height growth; some of these plots have been already abandoned, and for the remainder, proposals have been made and in part carried out by the Divisional Forest Officers concerned, for trying the effect of burning and removing overhead cover.

The results of past fellings under existing working plans have been studied, and memoranda recorded wherever possible.

It was found impossible this year to make any special studies of the natural regeneration of Sain (*Terminalia tomentosa*) with sal.

In Horai Block of Haldwani Division, in an area thrown out of the Working Plan on account of heavy damage from the drought of 1907, experiments are in progress aiming at replacing the dense growth of Ruini (*Mallotus philippinensis*) and other worthless species by *Terminalia tomentosa*, sal, or other trees of economic value; various methods of dealing with the understorey of weeds, which has occupied the gaps caused by the death of the standards and now prevents regeneration, have been tried and mound sowings are being done.

Statistical.—The bulk of the records of sample plots of the Forest Research Institute have been taken over during the year, and the remainder are to follow. The maintenance of these plots will henceforth remain in the hands of the Silviculture Division, though the Imperial Silviculturist will probably remeasure the plots near Dehra Dun. The following Forest Research Institute sample plots have been remeasured during the year :—

Species.	Division.	
	Haldwani.	Dehra Dun.
Sal	7	2
Sain	—	—

The number of sample trees felled for analysis has been considerably increased as the numbers taken at past measurements are altogether inadequate; a change has also been made in accordance with the recommendations of the Board of Forestry, from the volume curve method to the form factor curve method for calculating the volumes of the crops. The back checking of sample tree measurements has demonstrated only too clearly the reason for the anomalous results obtained in the past.

In addition to those plots eight new ones have been laid out during the year in Haldwani Division to fill in the gaps left in the series of diameter and quality classes, and to include the varying conditions of Hills, Bhabar, and Tarai. The plots have in all cases been made as large as possible.

This brings the total of sal plots measured during the year to 17.

The data for all the plots have been worked up in the standard form. It proved impossible to lay out *Terminalia tomentosa* plots as intended.

Besides the figures required for the compilation of yield tables, the measurements of these plots have also been used for preparing tables showing taper curves, spacing of trees in well-thinned plots, thickness of bark, etc.

Endeavours were made to obtain ring countings for sal wherever possible, and the results tend to indicate that at least a fair approximation of the age of a plot can be obtained by this method.

Artificial Regeneration.—Sal sowings in irrigated lines, and on unirrigated mounds formed part of the experiments tried in the Dolpokhra Plantation in Haldwani Division. The plants in the lines all died back during the cold weather, and except in the more favourable parts have failed altogether; this, as well as the complete

failure of the mound sowings, is primarily to be ascribed to the drought. The small plot of sal and Haldu (*Adina cordifolia*) in the Chorgallia garden continues its good development and in the cold weather 1920-21 the tallest stem measured 22 feet, being then 6 seasons old. Broadcast sowings under *Dalbergia Sissoo* are being tried this year at Dolpokhra.

No conclusive results have been obtained with Sain during the past year and, owing to the poor quality and quantity of seed available, but little will be done in the coming year.

The artificial reproduction of sal both by sowing and planting of root and shoot cuttings was continued in Gorakhpur. It has now been established that the planting of root and shoot cuttings is useless; the plants live if carefully tended but show no inclination to grow even after 5 years. Strip sowings both in the open and under cover are being investigated.

The ordinary attempts with artificial regeneration of sal by sowing in patches, without adequate tending in the rainy season, are utterly useless and should be given up altogether.

II. Miscellaneous Species.—The large scale work on the regeneration and general improvement of the miscellaneous forests of the Bhabar could not be initiated owing to pressure of other work, but arrangements were made for the coming year, the first step necessary being the closure to grazing of the selected area in Kalaga block of Haldwani Division. Sites have been selected for the experiment of diverting small streams to obtain regeneration of Khair (*Acacia Catechu*) and *Dalbergia Sissoo*, which will be tried out as soon as the closure can be effected.

At the instance of the local Silviculturist, the Special Forest Officer, Tarai and Bhabar, enclosed a portion of the dry bed of the Nandhaur River, near Chorgallia, to see the effect of protection from the intense grazing and trampling there prevalent, on the seedling crop of Haldu, Sissoo and Khair which already existed on the ground; the Haldu in particular is unusually abundant, but every year the new shoots are browsed down and a fresh start has to be made. A series of observation plots 15 feet square were selected and mapped for collection of precise records; these will be inspected as often as feasible until the new crop becomes established.

A commencement was made with sample plot work by laying out in Haldwani Division 8 plots in Sissoo crops. A fair range of diameter classes having been obtained the data are being worked up in the same way as for the sal.

III. Afforestation.—A considerable amount of work on the Bhabar species has been done in the neighbourhood of Haldwani by the local territorial officers under the advice and co-operation of the Silviculturist. Thus sowings, etc., were made in Dolpokhra, an abandoned village site, probably cleared originally in Bhabar sal

forest, and in 5 acres of miscellaneous forests in Kalaga, both in Haldwani Division; in Talli Haldwani Plantation in the Tarai and Bhabar Estate, and a start was made in a typical Tarai area near Lalkua, also in the Tarai and Bhabar Estate. Some work was also done in Boxar and Phulai of Kalagarh Division. Small scale experiments have also been made in the Haldwani Experimental Garden belonging to the Silviculture Division.

Sissoo shoot and root cuttings have already proved a simple and effective method and further areas were afforested in this way where irrigation was possible; shortage of water has held back development a good deal in many parts, but appearances indicate that this may only be a temporary check; water must, however, be freely supplied during the first season if satisfactory results are to be obtained. In Dolpokhra the shoots of almost every plant were killed back by frost in the cold weather, and there was a great deal of grazing, but the new shoots are mostly vigorous despite a minimum of irrigation.

Of the numerous other species tried by the same method, it was found that Siris (*Albizzia procera*) and Mulberry were successful and Lessora (*Cordia Myxa*) to a less extent, whilst all the rest were a failure.

Mound sowings of the following species were tried:—

Haldu (*Adina cordifolia*), Dhauri (*Lagerstroemia parviflora*), Bakli (*Anogeissus latifolia*), Semal (*Bombax malabaricum*), Sain (*Terminalia tomentosa*), Babul, Khair (*Acacia Catechu*), *Dalbergia Sissoo*, *Gmelina* and Bhaurang (*Hymenodictyon*).

Very poor germination was obtained with Haldu and Bakli, but on the whole, during the rains and early cold weather appearances were promising: the early cessation of the monsoon, followed by severe drought later on, has resulted in the death of a very large proportion of the young plants, only the Khair and babul having withstood it at all, except under exceptionally favourable circumstances, and even these species shew extremely poor development. This is disappointing, but can only be expected in drought years.

In the experimental garden, the Bakli regeneration both natural and from mound sowings made in 1919 is still apparent, but no start on vigorous height growth is yet to be recorded. Further experiments with bamboos are required but lack of seed has prevented their being done.

It becomes ever more apparent that for this class of work weeding is essential, at least during the first rains. Dolpokhra, which is the largest area dealt with, has been particularly unfortunate, having been submitted to every possible form of damage except fire.

The experimental sowings made in Lalwala of Saharanpur Division in 1920 were inspected by the Silviculturist in August 1920. Here three methods of cultivation are being tried, *i.e.*, complete ploughing, strip ploughing, and mounds. As regards the species best suited to afforestation work in the Bhabar the results are completely in accordance with those detailed above for Dolphokra—Khair and babul being the easiest to get established, Kanju (*Holoptelea integrifolia*) and Semal (*Bombax malabaricum*) fairly satisfactory, and all remaining species difficult. Of the three methods, the strip ploughing was most successful.

Several Divisional Forest Officers as well as the Forest Botanist have assisted with supplies of seed.

The question of Lantana eradication has been a good deal discussed; there is little question now but that the replacement of Lantana by Sissoo can be effected without difficulty wherever water is available for irrigation, but over much of the area water is probably better employed on agricultural crops.

The Benaik plantation of Naini Tal Division was inspected during the year and proposals made to the Divisional Forest Officer as to improvements in methods of afforestation with Kail (*Pinus excelsa*); no results have been recorded to date.

Research in ravine reclamation work was chiefly confined to the investigation of the causes responsible for the continued failure to get babul to grow in the Kalpi plantation. A pan caused by the flocculation of sodium carbonate and containing a higher percentage of this salt than babul will stand was discovered. The past failures are therefore easily explained. As a result of this discovery the proposal to extend afforestation in this neighbourhood has therefore been abandoned.

Experiments continued with many exotic trees in the Etawah ravines. *Terminalia Arjuna* germinated well but was killed by drought, *Hardwickia binata* promised well and its cultivation is being extended.

The question of soil cultivation has now been solved and reduced to a routine operation but finality as regards the best species of tree has not yet been obtained.

An investigation into the question of the inherited characteristics of babul seed is in hand.

The afforestation of the *chandas* of South Kheri and Pilibhit and the *phantas* of North Kheri is being investigated.

IV. Hill conifers:—*Twisted Fibre in Chir.*—Mr. Champion initiated a further series of experiments during 1920, mainly directed to the investigation of the effect of various kinds of injury to seedlings of known parentage; new sowings were also made on a limestone soil to confirm the conclusion previously reached that the chemical composition of soil has no influence, and to check

general results hitherto obtained. In any case a further series of sowings will be made in 1921 in Kaligadh Block near Ranikhet, as the existing areas are too inaccessible under present conditions of transport in Kumaun. Until the proposed inspection can be made, nothing further can be deduced from these experiments.

Statistics.—Six new Chir (*Pinus longifolia*) sample plots have been laid out in Chakrata Division to fill up the gaps of the Forest Research Institute plots which are particularly deficient in the more mature crops of the poorer quality classes.

The Almora plantations will be very useful for sample plots of all but Quality I, for ages up to 45 years and are about to be inspected to this end. Divisional plots are being examined and wherever possible adopted or adapted to present requirements; some of them as well as of the Forest Research Institute plots have not been considered worth maintaining, and in some cases two adjoining plots have been amalgamated to give a single plot of more reasonable size. By the end of 1921, it is hoped that sufficient plots will have been measured up to allow of the compilation of a tentative yield table for this species, though data will still be wanting for intermediate yields. The former measurements of the Forest Research Institute plots will be back checked as for sal.

V. Miscellaneous.—Experiments with Atlas "A" preservative and sodium arsenite solution in order to discover a sufficiently cheap solution for killing climbers and undesirable shrubs like *Mallotus* and *Clerodendron* have been carried out in many divisions and also by the Silviculturist. North Kheri reports that a 50 per cent. solution of Atlas gives as good results as the pure solution and that painting a girdle is more effective than a clean-cut surface. It is certain that Atlas solution will kill a large proportion of climbers treated but it is too expensive for employment on a large scale. The results with sodium arsenite have not yet been worked out.

A stump-pulling machine has been purchased for experimental purposes in the treatment of areas under regeneration infested with *Mallotus*.

The experiment of clearing undergrowth in Chir pine woods to see the effect, if any, on the yield of resin showed that the yield per 100 channels in two similar plots with and without the normal undergrowth was 5 maunds in the cleared plot as against 3 maunds in the control plot. The experiment is being continued until absolutely conclusive results are obtained.

Peridermium corticola still gives cause for anxiety in the Almora plantations and the investigation of the usual mortality of young Chir in these plantations has not proceeded any further.

VI. Working Plans.—Silvicultural research, statistical work and forest working plans are intimately bound up with each other

and have rightly been included in the same charge. The Working Plans and Research Circle has now been fully organised in close co-operation with the territorial charges and is fulfilling its functions in a satisfactory manner. The divisions of the work inside the circle has been settled and once a whole-time staff is available progress should be rapid.

An undoubted improvement in the quality of working plans has been brought about and an increased interest in silviculture is being developed among the executive staff.

VII. PUBLICATIONS.—The staff of the Research Circle have devoted part of their time to the preparation of scientific papers and newspaper articles for various publications. The correspondence in the "Indian Forester" on silvicultural systems for sal has been productive of much good. Mr. Smythies brought out his Afforestation of the Jumna ravines in Etawah (Indian Forest Records, Vol. VII, Part VIII) which has been widely distributed and is now being published in Urdu and Hindi. Mr. Benskin's book "Afforestation in the United Provinces" was also sent to press.

The Forest Pocket Book is in the press and should be found useful by every forester in Northern India. Besides much hitherto unpublished information regarding the artificial reproduction of the commoner species, a series of useful tables, including volume tables, for sal have been included. It is hoped that this little book will fill a long-felt want.

Punjab.

In the Kulu Division experiments to ascertain the best method of regenerating the high level spruce and silver fir forests were commenced just before the close of the year and will be dealt with in detail in next year's report.

Experiments are in progress in the Hoshiarpur Division to ascertain:—

(*a*) The correct cutting rotation of *Dendrocalamus strictus*.

(*b*) Whether the clearing of the clumps of the above bamboo affects the number and quality of new shoots.

(*c*) Whether a complete cleaning in one operation does not tend to the sub-division or splitting of the clumps.

The experiments are still in progress but as the results have probably been affected by the two abnormal years of drought in which they have been so far carried out; further observations are necessary before useful conclusions can be drawn.

An insect which bores from the tip of the shoots downwards is reported to cause the death of the culms.

In the Kalesar Range of the Simla Forest Division and the Nurpur Range of the Kangra Forest Division attempts at the

propagation of *Dendrocalamus strictus* by cuttings have brought the following points into prominence:—

1. Cuttings should not be planted on flat ground.
2. Cuttings under 4″ in girth are liable to result in failure.
3. Cuttings from culms of less than 2 and more than 4 years of age should be avoided.

Bihar and Orissa.

The sowing of sal in cleared lines in Samta Range, Singhbhum Division, in experimental areas 1, 2 and 3 in Compartments 16 and 17 has yielded very poor results. If the lines be cleared in valley type areas close to water they become paths for sambhar on their way to drink, and plants of Tun (*Cedrela Toona*) and Gamhar (*Gmelina arborea*) are invariably grazed back. Where the lines are not cleared as in Tirilposi Block, these species do much better and appear to escape the attention of game.

Fifteen per cent. of the sal have died and more are expected to die during the remaining dry months.

In two years a few sal seedlings have reached a height of 18″, Piasal (*Pterocarpus Marsupium*) seedlings 12″, Tun and Gamhar 36″. Weeding and loosening of the soil was carried out at a cost of Rs. 38-11.

Teak areas.—As the season was far advanced when teak seed was received only one seer was sown on an experimental scale; 119 seedling resulted and 17 were found dead after the rains. They were weeded twice, and a strong fence was put round them to prevent damage by wild animals. The total cost including fencing was Rs. 87-6-6. 70 seedlings are still alive. Experiments on this scale are obviously not profitable.

In Tirilposi Range. Area No. 1.—Sal sown on mounds in 1915. Some failed and some died back but threw up good shoots. They are partly under cover, and look healthy. Present height 8″ to 16″.

Toon of 1918. Sown on raised lines, doing remarkably well, tallest 13′ high, average height of others 11′ 6″ in the open.

Toon of 1918 transplanted.—Free from cover, average height 7′ 6″. Toon sown in January 1919 in nursery. The seed was bad, those which came up have reached 17″ in height.

Pterocarpus Marsupium.—Sown (*a*) on nursery beds in 1919, doing well, present height 7″ to 8″.

(*b*) On mounds and in lines. Those on mounds are more vigorous than those in lines, present height 5″ to 7″.

Sal.—Sown on mounds in 1919, mostly died owing to drip of a Pipal tree.

Sal.—Sowing in lines failed owing to lack of drainage.

Area No. 2.—Toon sown on raised mounds and lines in 1918, very successful in the open, height 7′ to 11′ 3″.

Toon transplants of 1918.—Damaged by sambhar but have thrown up healthy shoots 5′ to 7′ high.

Toon transplants of 1919.—Many died, height of survivors 3′ to 5′ 3″.

Sal sowing of 1918-19.—Failed entirely.

Area No. 3.—Sal sown in 1918 and 1919 in lines. Lines which are free from cover contain healthy seedlings. Lines under cover, very few. Rats are doing much damage.

Area No. 4.—(*a*) Sal sown in nursery beds in 1918. Condition good, overhead cover has been removed.

(*b*) Sal sown on mounds in 1918. Most died, rats killing many of them. Condition of survivors fair.

(*c*) Sal sown in line 1919. Area water-logged and under heavy cover. Lines which are free from cover contain healthy seedlings.

(*d*) Toon sown in 1918, transplanted in 1918. Most killed by sambhar, survivors 3′ to 3′ 6″.

Area No. 5.—Sal sown in lines 20′ apart with paddy in between 1918. Owing to the damage by wild animals the crops failed and were abandoned. Such areas must be fenced. Sal in water-logged soil turned yellow. Sal on slopes fairly healthy.

Area No. 6.—Natural reproduction of sal under cover. All seedlings died owing to water-logging and too much cover.

Area No. 7.—Well stocked with healthy natural seedlings, on low ground fewer but sufficient to stock. Weeding has been done and was necessary.

Blank Area.—Sowing of sal in August 1918, a failure owing to bad seed. There has been no seed since.

Group Area.—The sowing of sal and Piasal seedlings in 1919. A fair number of survivors, condition good.

Strip Area.—Sowing of sal, Piasal and Toon in 1919. The first two species are doing well. Ground appears unfavourable to Toon which have turned yellow and are dying.

Afforestation.—Eleven half acre plots were laid out in Khandata block, Sambalpur Division, one of a number of blocks which were reserved in 1916 and contain no forest growth. The soil is a sandy loam of moderate depth and the situation flat. Of the eight species sown teak, *Pterocarpus Marsupium*, and *Gmelina arborea* are likely to prove most useful for afforestation purposes but the experiment is not far enough advanced to allow of definite conclusions being drawn.

A series of experiments was carried out in the Angul Division to determine the best method to regenerate sal and teak in this Division. The experimental areas were not kept under proper observation and consequently no authentic written records exist, especially in the case of sal, which could convey reliable and accurate information.

Information given below, though not so accurate as it should be in such an important case, is, however, sufficient to draw conclusions from, which would not be far off the mark.

SAL.—Five plots, each about 2 acres in extent were selected in Purnakote Range.

Plot A.—Left to be naturally regenerated.

Nothing whatsoever was done here except the burning of undergrowth. It was a failure, attributable perhaps to the flames having risen so high as to destroy the vitality of seeds.

Plot B.—Soil was hoed up after burning the undergrowth. Result same as above.

Plots C. and D.—Were treated alike. Seeds were dibbled in after hoeing up the soil, undergrowth having been first burnt.

Plot E.—Soil was treated as in C and D but seeds were sown broadcast.

All the above operations were carried out towards the end of March 1919. Germination except in Plots A and B was quite satisfactory. Seedlings did not come up thick as grass, and it was at that time thought that further operations were not warranted by the degree of success attained.

Weeding was carried out in August and was half-heartedly done. Still there are enough seedlings on the area to make a fair crop. All the seedlings which survived are healthy and strong.

No records exist to give cost of carrying out the above experiments.

TEAK.—Sixty lines 10′ wide and 20′ apart were prepared. All the growth, mostly consisting of evergreen species and bamboos, was cut and burnt.

Pits about 8′ apart were dug on cleared lines and filled with humus and ashes and mounds made in March 1920. The mounds were 6″ in height and 1′ in diameter.

Seeds were obtained from Burma and Madras and were dibbled in the first week of June. Those from Burma showed the better results, germination having taken place in the middle of July.

Unfortunately 20 lines were entirely destroyed in Purnakote Range by wild elephants during the drive in the last Khedda Operations. The rest of the lines show promising results. Watering was done during October and November twice a week. Weeding was done in September and mounds were loosened in January except in four lines. The loosened mounds showed much better results than those not loosened. About 200 seedlings were transplanted. The transplants do not show any marked advantage over the seedlings while a considerable number of them have already died. Transplantation involves a certain amount of risk because if not properly done roots are exposed. Some expenditure is also involved in the operation. No transplanting will be done in future.

Watering will also be dispensed with because it has been noticed that only a very few of those plants which were not watered failed to survive.

Results obtained warrant a continuation of this work.

The experiment of destroying climbers by applying creosote oil to the stumps has not proved as successful as was anticipated, several of the treated stumps having again thrown out shoots.

In the Puri Division an area of mixed forest was selected containing an upper-storey of sal with underwood and undergrowth of dense evergreen forest, and little or no sal regeneration on the ground. All the evergreen growth was cut, and a thinning made in the sal crop. The area was then divided into 3 plots; in the first of which all the cut material was burnt and the soil ploughed up. In the second only burning was done, and in the third plot neither burning nor ploughing was undertaken. All three plots were then densely sown up with sal seed collected from the adjoining forests. All these experiments were completed in June 1920. The area was last inspected in February 1921, and it was recorded that the experiments were giving satisfactory results. The whole area (especially plot No. 1, burnt and ploughed) was covered with sufficient seedlings to establish a dense stock. The seedlings varied in height from 6″ to 1 foot and appeared very healthy. It will now be interesting to note what effect the dry season has on the growth of these seedlings, and if they will show signs of dying back, a possibility which is hardly expected in this moist climate. In this connection it will be possible to record more definite results next year.

Further experiments on a more extensive scale are to be undertaken this year with a view to ascertaining the cheapest method by which effectively to regenerate large areas with sal, and to establishing regeneration by natural means as far as possible, aided by cutting and burning of the dense evergreen underwood and undergrowth which has such a deleterious effect on the young sal.

A peculiar phenomenon noticed in connection with last year's experiments in the adjacent forests where the fire had spread and burnt the smaller undergrowth and leaves, consisted in observing that although the ground was covered with a mass of sal seedlings which had sprung from seed given by parent trees, all these seedlings were in a most unhealthy condition and many of them had already died. The cause of death was attributed to one or other of the following factors, excessive dampness and "drip" caused by the shade of the evergreen and accentuated by "sourness" and lack of aeration in the soil. In peculiar contrast to this, under exactly similar conditions of shade and cover, it was observed that in areas *not burnt* the seedlings were all surviving, and in appearance much more healthy and vigorous,

This condition of affairs is so contrary and so radically opposed to all established beliefs and opinions that further research is essential before advancing any theories on the subject. It, however, tends to show that burning alone without opening of the cover is harmful.

Casuarina.—Investigations carried out in the *Casuarina* plantation distinctly prove that the *Casuarina* seedling is highly susceptible to any mal-treatment of the main taproot. If the main root is damaged, very long lateral roots are developed which do not reach the lower layers of moisture-laden sand with the result that the growth of the plant is very much retarded, and in many cases ends fatally. Even partial damage to the roots causes the tree to assume a bushy growth.

Teak.—Teak seed buried in the soil, covered with alternate layers of straw, and watered regularly for a fortnight produced much healthier and stronger seedlings than seed treated by the old method of soaking in water for 48 hours prior to sowing.

Bengal.

Natural reproduction of valuable species in the hills is exceedingly scarce, or altogether absent.

Kawla (*Machilus odoratissima*) produces a fair quantity of seedlings, but the growth of this species is so slow that it cannot be considered one of our economic species.

Buk (*Quercus lamellosa*) and Phalat (*Q. lineata*) seeded profusely this year, but very few natural seedlings appeared on the ground; bears and insects, especially the latter, probably consume most of the seed before it can germinate.

Pipli (*Bucklandia populnea*) produced a fair quantity of seed, but large seed-bearing trees are very scarce in the forests, having mostly been cut out in accessible places, and we cannot expect much natural reproduction of this species, as such trees as remain are usually found in dense forest where the conditions are not favourable for germination of the seed.

Cryptomeria japonica promises to produce excellent natural reproduction where there are mature seed-bearing trees and sufficient light; but we have no large areas of mature *Cryptomeria* and the possibilities in this direction can only be seen at the Cinchona Department's plantation at Mungpoo. In any case it is probable that artificial planting of this species will prove the quickest and most effective way of restocking an area, as it transplants easily, and is easily raised in a nursery.

Champ (*Michelia excelsa*) seeded very badly again, and there is scarcely any natural regeneration.

Walnut (*Juglans regia*) produced a fair quantity of seed, but natural seedlings are seldom found.

Kimbu (*Morus lævigata*) and Panisaj (*Terminalia myriocarpa*) produced plentiful seed but scarcely any natural seedlings and these few are almost certain to be destroyed by game.

Utis (*Alnus nepalensis*) as usual seeded well, but it only seems to reproduce itself naturally on landslips and places where the soil is exposed and there is plenty of light.

Of less valuable hill species, Kapasi (*Acer Campbellii*), Arupati (*Prunus nepalensis*), Maya (*Eriobotrya petiolata*), Saur (*Betula cylindrostachys*) together with Kharani (*Symplocos theæfolia*), Kanakpa and a species of Hill Mallatta (*Macaranga spp.*) reproduce themselves fairly well, especially the three latter.

In the sal forests of the plains, natural regeneration of valuable species is also very scanty; in the dense forests, because of the unfavourable condition of the soil as a seed bed, and owing to insufficient light for development of seedlings; and in more open ground owing to prevalence of heavy grass, fires and game, which seem to do more damage in such places.

Of the more valuable species Lattar or Cham (*Artocarpus Chaplasha*) and Champ (*Michelia Champaca*) produce a certain amount of natural regeneration and seem to be gradually coming in among the sal, especially in the moister parts. Seedlings of *Artocarpus* have frequently been observed when there was no sign of the parent trees, and which must have been sown by birds or monkeys; but it is very seldom that such seedlings get through, as they are nearly always eaten down by game.

Cham seedlings are also badly damaged by game, and recently at Panchnai a great quantity of Cham seed under a fair sized tree was found to have been destroyed by mice; parrots and birds also devour the seed on the trees just when they are getting ripe; so that at the best only a small amount of natural regeneration occurs.

Of the less valuable species Pitraj (*Amoora Rohituka*) produces plenty of natural seedlings; and in the more open ground Simul (*Bombax malabaricum*) and in the sandy river bed forests Tun (*Cedrela Toona*) produce good regeneration. This natural growth of Tun seedlings is particularly noticeable in the neighbourhood of the Hiapatha coupe in the Jalpaiguri District. Kadam (*Anthocephalus Cadamba*) reproduces itself plentifully in old taungyas and cultivated areas. Khair (*Acacia Catechu*) and Sissu (*Dalbergia Sissoo*) produce good natural regeneration along river banks at the foot of the hills, but they are terribly damaged by grazing of cattle, deer, elephants, etc.

Mandani (*Acrocarpus fraxinifolius*) produces splendid natural regeneration in clear-felled and cultivated areas along the foot of the hills, generally associated with Kadam, and a certain sprinkling of Lampati (*Duabanga sonneratioides*). Examples of this can be seen at Pundigin the Kurseong Division, and most noticeably in

the Meanglass coupe in the Kalimpong Division 1920 area. Gamhari (*Gmelina arborea*) has also produced large numbers of natural seedlings in similar areas in the Chittagong Hill Tracts, probably due to the proximity of forest villagers preventing bear and game from eating the fruits.

Sal.—It has been a really bad seed year, though at first everything promised well, but two exceptionally severe hailstorms on April 14th and May 27th, stripped nearly all the fertile seed from the trees.

Mahogany (*Swietenia macrophylla*) in the plantation at Kaptai, in the Chittagong Hill Tracts Division produces abundant natural seedlings, and judicious thinnings amongst the useless species immediately to the north of the plantation, together with climber cutting, will certainly lead to a gradual extension of the plantation by natural means. This was suggested to the D. F. O. in June last and when the plantations were again visited in November, there was a great improvement in the growth of these natural mahogany seedlings. They were coming up in thick patches with perfectly straight stems, some of them already over 25 ft. high. They reach this height in 3—4 years under favourable conditions.

Garjan (*Dipterocarpus sp.*) and Tali (*Dichopsis polyantha*), two of the most important indigenous species in the Chittagong Hill Tracts Division, produce abundant natural seedlings but the problem of how to regenerate these forests by natural regeneration has never been solved. The seedlings may be on the ground in thousands, but they will not develop under the dense shade. Immediately light is let in, the whole area is invaded by a tremendous growth of creepers, with which no seedlings can compete, and as the creepers would have to be cut several times in a year, probably for several years, to do any good; the expense would be prohibitive.

Artocarpus Chaplasha another of the economic species of the Hill Tracts (very high prices are paid for large dugouts made from these trees, in which most of the trade of the district is carried on) also produces plentiful natural seedlings, but they are almost invariably destroyed by game.

The following is a brief account of *Artificial Regeneration* in the Hills and Plains with some account of the principal species which it is attempted to reproduce.

Pipli (*Bucklandia populnea*) and Utis (*Alnus nepalensis*). In Darjeeling and Kurseong Divisions small group fellings and blanks are planted up with the more valuable species such as Pipli and Utis which make an excellent mixture, the Utis being a fast growing light demander and the Pipli a shade bearer, which benefits by the presence of the Utis, as the latter protects it from frost and at the same time draws it up. In the Darjeeling Division

Pipli plants are kept 2 years in the nursery, and put out in the forest at the beginning of the 3rd rains, while in Kurseong Division at lower altitudes, the plants are only kept one year in the nursery. One year old plants of Utis are used, that is they are kept in the nursery through the first cold weather. Unfortunately Utis is rather too big to plant, sometimes being 3 or 4 ft. high by the 2nd rains which causes a great check to the growth when put out, while it is thought to be too small to put out in the first rains. It is thought however that if the shades are removed from the pricking out beds early, plants could be put out quite well in the first year without being kept through the cold weather in the nursery.

Saur (*Betula cylindrostachys*) is not in favour with the local people, though it gives an excellent fuel. It is usually planted pure and plants should be put out from the nursery when five months old. If kept in the nursery for a year, they are much too big to give good results; Saur does not transplant well, and for that reason not much of it has been tried this year.

Mandani (*Alcrocarpus fraxinifolius*) is only now being experimented with by the Forest Department in artificial regeneration. It germinates readily when sown in a nursery bed, and transplants well; good results can be seen in the Kurseong Division, in the Taungya at Kadma and also at Mohurgong plantations where plants put out last June from the nursery are now 12 to 15 ft. high. Mr. Russell of the Cinchona Department however had excellent results by direct sowing with this species on a dry exposure in the hills, sowing in April and May. It is likely that wherever the soil is cultivated in the foothill country and up to 2,000—3,000 feet good results can be obtained by direct sowing. The growth is very fast and straight, 12—20 feet in $2\frac{1}{2}$ years from seed, and it is an excellent constructional timber growing to a very large size in the Kalimpong Division. The difficulty is to get range officers to collect sufficient quantities of seed.

Cryptomeria japonica is planted pure in taungyas or at any rate in pure groups, two year old plants being used in the Darjeeling Division, and one year old plants in the Kurseong Division. It germinates readily in the nursery in shaded beds, and seedlings can be pricked out in July, and put out in the forest the following June or July. The wood is very light and excellent for battens, rafters, planking, tea boxes, etc., and does not appear to be eaten by white-ants.

Hill Champ (*Michelia excelsa*) is usually planted in small groups pure, or in mixture with Pipli, Utis, Oaks, etc., and most excellent results have been obtained where villagers can be induced to cultivate potatoes.

If cultivation of the soil is obtained, Champ puts on a shoot of 3′ to 3′ 6″ and even 3′ 8″ in its second year planted out. Again

it is not definitely settled whether one year old or two year plants are the best. Also cold weather planting, after stripping the leaves, gives as good results as rains planting; Walnut is sown in a nursery about February or March, and planted out the following cold weather in jhoras. A curious fact about this species is that we have found the seed germinates much better in beds without any leaf mould.

Kimbu (*Morus lævigata*) is still in the experimental stage as far as the Forest Department is concerned; it is not common everywhere except in the Tista valley. The practice has been to keep it in the nursery through the cold weather, and put it out in the forest at the beginning of the 2nd rains after root and shoot pruning. Last year it was noticed that most of the young Kimbu at Mangpoo from about the 6th year or so are attacked by a large borer; and specimens of the larvæ were sent to Dehra Dun for identification. The entomologist says that it is probably the same longicorn beetle which does so much damage to the Mulberry trees in Japan, but which had not been reported from India before. Plate II shows Kimbu in the plains planted out some 14 months.

Panisaj (*Terminalia myriocarpa*) in former years was greatly cut out for furniture and cabinet work and now large trees are rare. It is difficult to obtain good germination of the seed; it should be lined out in a nursery and planted out in its first rains in July. It is much damaged by game in unfenced areas. In Kalimpong it is also sown direct in lines in Taungyas with success. Its growth is rapid, and fencing and planting in moisture localities is all that is required for good results.

Oaks and Chestnuts are difficult to grow on account of the uncertainty in obtaining sufficient good seed. The seed should always be tested by floating in water, when the good seed sinks and the floaters are thrown away. It is stored in a pit at least 4 feet deep during the cold weather to guard against insects. It can be either sown direct, two or three selected seeds in a thali (or planting hole) or seedlings kept in the nursery for 3-4 years and put out root and shoot pruned.

Arupati (*Prunus nepalensis*) has been sown direct in the Darjeeling District in prepared thalis; and is considered a good species from 7,000'—8,000' being frost hardy and not attacked by game. It does not transplant well.

Before leaving the question of artificial regeneration in the hills it is necessary to say something about the Taungya system.

Briefly, as applied to Bengal it consists in clear felling an area, burning it in the dry season, after removal of the timber and firewood, and raising field crops with cultivation for at least one, and if possible two years in succession, and at the same time sowing or

planting up the area from the first year with valuable species of trees.

The success of the system depends upon three main points—

(1) Sufficiency of labour.

(2) Fencing against game and cattle.

(3) Good nursery work.

If sufficient labour is available, conditions 2 and 3 are absolutely essential to success. Everywhere, more especially in the plains, the hopelessness of the task of trying to raise young plantations without good fencing is apparent. Money must be spent without stint on game-proof fencing. Given the necessary labour and good fencing, the final basis of success is undoubtedly good nursery work.

Without a good nursery of adequate size, and stocked with a large reserve of good healthy seedling plants, blanks in direct sowing cannot be filled up, fully stocked young plantations could not possibly be obtained, and many of our most valuable species which are very small and delicate in the seedling stage could not be grown at all.

The secret of success is to obtain a fully stocked area from the start, as this means that after the 2nd or 3rd year, the fully stocked area begins to close up, and weeds and creepers are kept down by the shade of the young trees, after the villagers have left the area; so that further expenses of creeper cutting and cleaning are largely reduced.

The principal species in our plains forest is of course sal. In Kurseong Division it is raised by direct sowings in lines 6 or 8 feet apart together with the cultivation of crops on the Taungya system. In Buxa and Jalpaiguri Divisions, it is raised on the Taungya system and also by sowing hoed lines 3 feet wide and 6 feet between the lines of seedlings, leaving 3 feet between the hoed strips. This gives quite good results provided the jungle can be kept down between the lines.

The plants should be 3 feet high by the end of the 2nd rains, and 6 feet to 8 feet high by the end of the 3rd rains, by which time they can be considered fairly established. No attempt has so far been made to grow Khair by artificial means.

Dalbergia Sissoo is one of our most neglected valuable species, it grows very well throughout the Jalpaiguri and Buxa Divisions especially in Buxa, where trees of 7 ft. to 8 ft. girth are frequently met with. The chief difficulty is to obtain labour for cultivation in the shallow river bed areas, where the species grows well naturally; and also it must be fenced against game.

Satisal (*Dalbergia latifolia*).—Not much success has been obtained with this species. Seed was obtained again this year and sown in nurseries in Kurseong Division, but it did not germinate well, and a few plants put out last year seemed to show a slow rate of growth.

Kainjal (*Bischofia javanica*) which grows very successfully in moist depressions in the plains, was again largely sown this year. Six months' old seedling transplants from a nursery are used. Fencing against game is again essential, otherwise every plant is eaten.

Lali (*Amoora Wallichii*) is still in the experimental stage. Some plants put out at Panchanai, late last rains, survived the drought of the cold weather well, but seem to show a rather slow rate of growth. They are not more than 18 inches high now, when a year old.

With Chapalish or Cham (*Artocarpus Chaplasha*) excellent results have been obtained in the Chittagong Hill Tracts by direct sowing at stake in prepared thalis in Taungyas. During the period under report, thousands of young Chapalish trees were established in the large 1920 Taungya of 120 acres in the Chittagong Hill Tracts in this way. In North Bengal Divisional Officers have as yet only tried it in nurseries, with a view to transplanting it at the beginning of the 2nd rains. It appears then to be too big, and direct sowing in Taungyas with cultivation is the best way to grow it. It is an important tree of rapid growth, and should be 6 feet to 7 feet high when 18 months old, and 10—12 feet high in 2 years.

Toon (*Cedrela Toona*) can either be put out by direct sowing in lines of thalis in taungyas, or seedlings can be transplanted in the first cold weather from the nursery or one year old plants be cut back root and shoot pruned.

Chickrassi (*Chickrassia tabularis*) is planted out from a nursery when 6 months old, but it can also be planted out in the first cold weather. Seedlings are then ready for transplanting into the taungya. This year it was tried in the Chittagong Hill Tracts with great success at Kapti in the 1920 area and thousands of plants were successfully put out. It can also be sown direct in the same manner as Toon, but the plants are not so large in the same time as they are where nursery plants are used. This was very noticeable in the Hiapatha coupe of the Jalpaiguri Division.

Simul (*Bombax malabaricum*) is best sown at stake in taungyas, and $9' \times 9'$ planting is close enough. It germinates well but several seeds are best sown at stake, to obviate the necessity of transplanting which it does not stand very well.

Gamhar (*Gmelina arborea*) is usually sown pure, direct in taungya after removing the pulp from the seed. If not sown

pure it outgrows everything else, which it suppresses, and then itself becomes branchy. Great quantities of seed were sown this year in the 1921 Taungya in the Chittagong Hill Tracts, and it has been most successful.

Plains Champ (*Michelia Champaca*) seed is ripe in August, a most awkward month, and there is always difficulty in obtaining sufficient seed. Seedlings cannot be put out and established before the first cold weather drought comes on, and many seeds do not start germinating till January and February. Seed therefore has to be sown in a nursery, in shaded beds, and seedlings kept in the beds till the following June when they are too big for satisfactory planting. However, it can be successfully pricked out into bamboo chungas. This retards the growth to some extent but makes transplanting it a practical certainty.

Mahogany (*Swietenia macrophylla*) is being tried on a very small scale in the Chittagong Hill Tracts Division where it shows great promise, and reproduces itself naturally, producing abundant seedlings. It reaches 10—12 feet high in 2 years and 20 feet in 3 years. As the "Tub" method of germinating the seed (soaking in a tub and drying for 15 days) has given very good results, the prospects seem quite promising. It is thought the best method would be to plant it in mixture with some suitable shade bearing species, if any can be found which nearly approximates to its rate of growth. Mahogany in the Chittagong Hill Tracts Division and Toon and Chikrassi elsewhere seem promising in this direction.

Jarul (*Lagerstræmia Flos-Reginæ*) has only been tried on a small scale in the Chittagong Hill Tracts. The seed germinates well but its growth is slow, and it needs to be planted close, as it tends to be very branchy.

In September, nine temporary sample plots were laid out and measured by the writer in the plantations at Mangpoo, the species being Pipli, *Cryptomeria*, Saur and Utis, and the figures are being sent to Dehra Dun for working out the calculations, the idea being to obtain figures for the rates of growth of these species.

Of experiments tried the following may be mentioned:—

(1) The planting of Champ (*Michelia Champaca*) in bamboo chungas at Kurseong. Result successful.

(2) The planting of *Artocarpus Chaplasha* root and shoot pruned in Buxa, when too large for ordinary transplanting. Result successful.

(3) Winter planting of Toon, Chickrassi, Kimboo and Champ (*M. Champaca*) stripping the leaves. Result—The three former successful, the latter a failure.

(4) Planting of Pipli and Utis stripping the leaves; successful (Kurseong Division).

(5) Planting of Utis (*Alnus nepalensis*) first year seedlings without pricking out (Kurseong Division) result very successful. This adds 4 feet in height growth to our plantation by the end of the 3rd year.

(6) Seed percentage of germination test of Gurjan in Cox's Bazar Division. Result not yet reported.

The most important Silvicultural publication completed during the period under report, was the "*Nursery Notes for Bengal*" which was written by Mr. Shebbeare and Mr. Teague from these officer's notes and those of Mr. Russell when he was at the Cinchona plantations at Mangpoo. These notes are now being published as a handbook of convenient size for the use of rangers, foresters, and such others of the Department as may choose to avail themselves of it.

Up to date there has been no book of reference in Bengal which gave the seeding and fruiting times of the principal species; and with many new men filling up the Department who have had little experience of the work, it is hoped that the handbook will be really useful.

Assam.

The evergeen forests of Assam offer difficult problems in that they are composed of a large variety of trees, only a few of which are of economic importance. Exploitation under the selection system does not result in the reproduction of the valuable kinds and experiments have been undertaken to ascertain the best method of cultivation. Three distinct types have to be dealt with:—

(1) *Forests in which there is a sufficient number of mother trees of the more valuable species.*—Of the various experiments carried out in this type of forest the most successful are those in the Nambor and Diphu Reserves. Plate III gives a good idea of the natural regeneration of Hollock (*Terminalia myriocarpa*), *Phoebe attenuata* and Khokan (*Duabanga sonneratioides*) that has sprung up all over plot No. 1 (7 acres) Nambor Reserve and a recent enumeration of seedlings gives the following results:—

Duabanga sonneratioides	200
Terminalia myriocarpa	100
Phoebe attenuata	200
Artocarpus Chaplasha	60
Bischofia javanica	62
Cinnamomum cecicodaphne	4
Gmelina arborea	1
Tetrameles nudiflora	60

This was obtained by merely removing everything except the mother trees and by cutting and burning the undergrowth. The seeds fell in 1919. The crop of *Phoebe attenuata* seedlings which

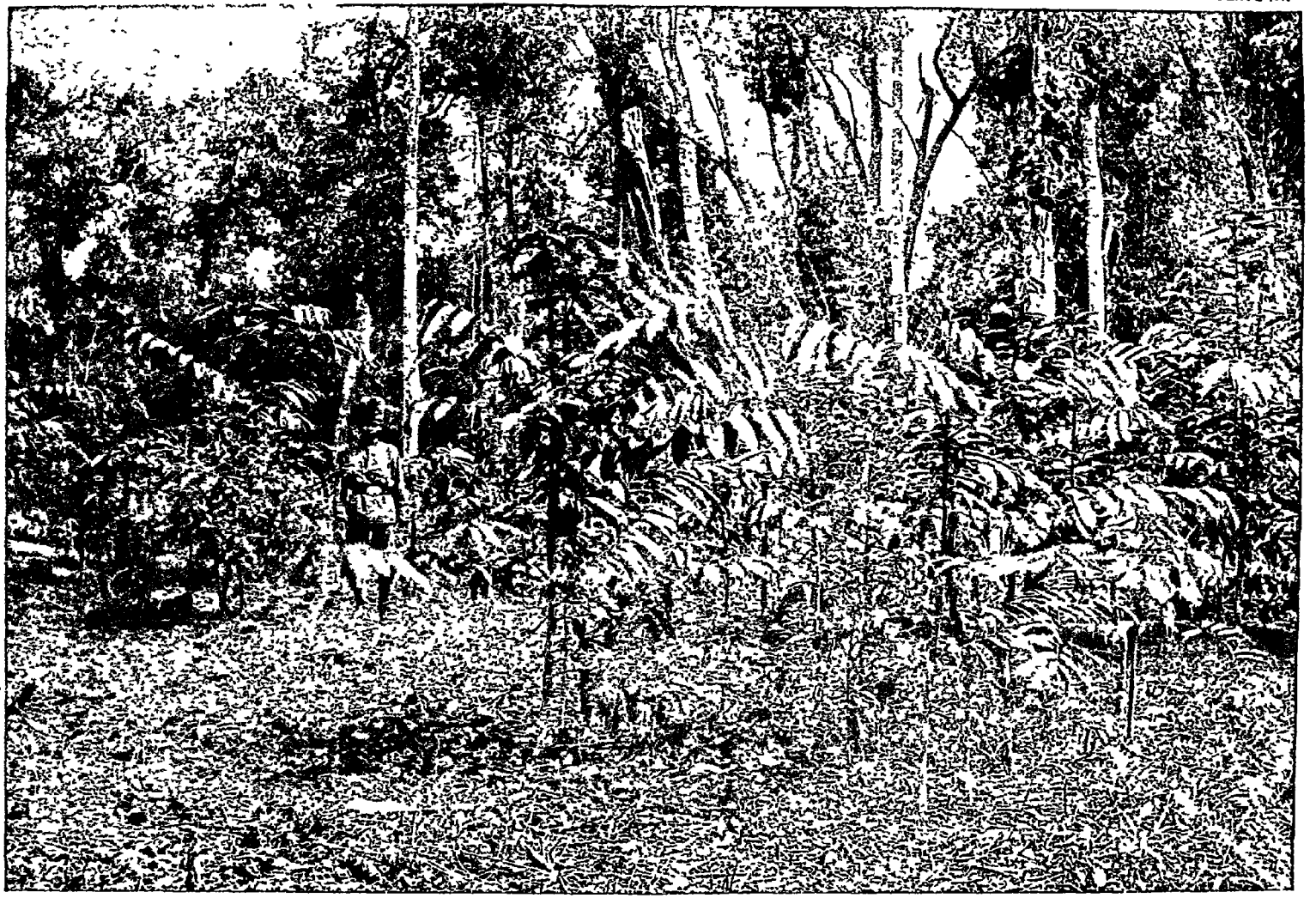


Photo.-Mech. Dept., Thomason College, Roorkee.

Photo. by A. K. Adhikari.

has resulted from the 1920 fall is too large to enumerate. The greatest height of *Duabanga sonneratioides* is 16 feet and of *Terminalia myriocarpa* 8 feet.

Good results were also obtained from other plots and it is considered that the work is proceeding on right lines so that it should be possible within the next two years to prepare a reliable working plan for this type of forest based on these experiments.

(2) *Forest where there is an insufficient number of mother trees of the more valuable species.*—In this type intensive climber cutting is first carried out followed by clearing of the jungle under the seed bearers. Fire has also been used to burn the slash but encouraging results have been obtained both with and without its use in the case of *Phoebe attenuata*.

This operation obviously would not restock the ground completely and an experiment has been commenced over 5 acres in which the whole of the woody growth has been removed and burnt, in part of the area, while in the remainder only large trees have been left standing. The object is to join up the groups artificially which have been established under the parent trees. *Phoebe attenuata* has been sown and has thrived best in the shade where weed growth is less luxuriant but it is recognised that two weedings in the first year and again in the second year are essential to success.

(3) *Forest where valuable trees are absent.*—Here the experiments have so far not given very definite results although *Amoora Wallichii* has done well. This type is composed of a mass of soft woods and climbers which are usually the result of a secondary growth following upon temporary cultivation. The type covers large areas. At the outset the climbers are cut and the area sown or planted at intervals of $6' \times 6'$, the overhead cover being removed when the plants have reached the sapling stage. A similar problem is being investigated in the large areas covered with *Dendrocalamus Hamiltonii*, the bamboos being felled and burnt and seeds dibbled in at intervals of $6' \times 6'$.

Observations have been recorded of the silvicultural requirements of the principal timber trees and of the injuries from natural causes to which they are subjected.

Attempts are being made to induce the hill tribes to sow the seeds of fast growing trees in their temporary cultivation. *Betula alnoides* is used in the Naga Hills and *Grewia multiflora* in the Mikir Hills. The Nagas however seem to prefer to allow the exotic *Eupatorium* to invade their land as the rotation is said to be as low as two years with this plant and to result in excellent crops even after this short interval.

The value of "Atlas Compound" to kill trees has been definitely proved in the Lakhimpur Division the matter resolving itself into one of the cost of the compound.

Central Provinces.

In the Melghat Division experiments are being carried out to find (*a*) the effect of removal of shade on teak seedling growth, (*b*) the best method of obtaining germination of teak seeds and (*c*) the suitability of planting teak seedlings in a clear felled area; but definite conclusions have not yet been reached.

One thousand coffee plants were planted at Bairat in shade on a south slope in June 1920 and when last counted 850 were still in leaf and a number more should revive when the rains break.

Regeneration.—Four sal regeneration plots, each of three-quarters of an acre, were permanently demarcated in South Raipur Division near Sitanadi Forest Bungalow. The seedlings of the year (an excellent one) were counted and were respectively 19,000, 18,000, 16,000, 15,000 in plots I, II, III, IV. The plots were treated as follows:—

Plot I.—Untreated for comparison purposes.
,, II.—In March 1920 all low cover was felled and the upper canopy opened by a "light" thinning.
,, III.—In June 1920 treated as plot II but the "light" thinning was heavier.
,, IV.—In March 1920 treated as plot II but clear felled in June 1920.

In order to make the results clear it may be stated that the South Raipur forests are situated in a frost-free tract, the soil is apparently well aerated and natural regeneration usually excellent. It is too early to draw any conclusive results from the experiment but plot IV (clear felled) looked extremely encouraging in March 1921. The ground is thickly carpeted with seedlings a few inches high and apparently very healthy; though the number enumerated is undoubtedly much reduced yet those surviving are more than sufficient to restock the area and have a very promising appearance. In addition to the above all the cut back advance growth of sal has coppiced magnificently and several shoots were measured eleven feet high, the majority being 3′ 6″. The area has every hope of successful and complete regeneration. Plots II and III are similar but the results not nearly so good. They appear to prove the theory that sal regeneration requires complete removal of top cover.

The sample plot created in Khairi Range, Jubbulpore-Narsinghpur Division in 1906 to ascertain the reproduction of frost-bitten teak trees was measured in January 1921 and the results show very slow growth.

In Saugor Division measurements of thinned and unthinned coppice shoots are being carried out.

Bombay.

Growing *Casuarina* without water has been tried in three places. In one place where the ground is hard and low the result has been failure but in the other two places the experiment is expected to be successful.

The experiment of applying green leaf manure to *Casuarina* plants to minimise watering expenses was tried in January. About half a head load of green *soppu* was spread around each plant over about an acre. The plants are in good condition and further results will be given in next year's report.

Madras.

During the year the following sample plots were transferred by the Imperial Silviculturist:—

(I) *South Malabar District.*—Eight sample plots in Nedungayam to ascertain volume increment and development of teak plantations at different ages, on different soils, and under different conditions of treatment. They were laid out originally in 1916-17.

(II) *Tinnevelly District.*—Near Mundanthorai, two sample plots dealing with volume increment and development of teak coppice with standards, and two sample plots dealing similarly with the teak plantation near Kariar. These four plots were laid out in 1916-17.

(III) *South Cuddapah District.*—One volume increment sample plot of *Pterocarpus santalinus.*

The second series of measurements in all the above Dehra Dun plots should be recorded in 1922, five years after the first.

(IV) *North and South Mangalore Districts.*—One sample plot in Parappa to record the periodical girth and height increment of *Hopea parviflora* was taken over from the District Forest Officer, South Mangalore.

Besides the above, five sample plots were opened during the year, of which two, in the Devechala Reserve, are to record the girth and height increment, and the number of stems and volume increment of *Hopea parviflora.* The remaining three sample plots comprise two in the Nalkur reserve, to ascertain the periodical girth and height increment of *Hopea parviflora,* and one in the Pilarkan reserved forest, dealing with the number of stems and volume increment in a pure crop of *Hopea.*

There are 17 experimental plots in the deciduous forests at Dhoni, which have for their object the following:—

(*a*) Twelve plots for the study of the method of converting the existing deciduous forest into evergreen by the sowing of *Hopea parviflora* (five plots), *Artocarpus hirsuta* (five plots), *Vateria indica* (one plot) and *Mangifera indica,* the wild variety. (one plot).

To come to any definite conclusion from the above experiments would be premature, as certain factors should be considered, such as the poor fertility of seed of any particular year, unusually severe drought, possible carelessness and apathy on the part of subordinates and so on. So the same experiment in the same plots will be carried out in 1921-22 with slight check-modifications. For the present it may be assumed that:—

(1) To establish a crop of *Hopea parviflora*, *Artocarpus hirsuta*, *Vateria indica* or *Mangifera* in a clear-felled area of deciduous forest is very difficult if not impossible.

(2) That for these plants to survive the scorching days of summer they must have overhead shelter, and be protected from the afternoon sun.

(3) That consequently, in a purely deciduous forest thinly stocked with trees, all of which are completely deciduous, and whose stems and branches alone are insufficient to throw an appreciable amount of shade on the ground, it would be impracticable to raise directly a crop of the evergreen species enumerated above in localities where drought is severe and long in the hot weather.

(4) That the condition that every tree is completely leafless in the summer months is not normal, at least in the deciduous forest near the locality experimented with, where *Schleichera trijuga*, *Trema orientalis*, *Dalbergia sissoides*, *Albizzia Lebbek* and *procera*, and *Swietenia macrophylla* are in full leaf even in March, the hottest month. The last-named species, though in reality an exotic, is now reproducing itself naturally here. So by a preliminary step of increasing the proportion of such hardy light-demanding evergreen species in a typically deciduous forest, if attended with success, there is every reason to expect good results from the subsequent introduction of valuable shade-bearing and shade-demanding evergreen species in localities where the rainfall is sufficient.

(5) That the weeding of plants in their infancy tends to lessen the number of casualties.

The remaining five experimental plots in the Dhoni deciduous forests have for their object the establishment of a pure crop of deciduous species in deciduous forest of mixed species.

Nursery work.—Experiments have been and are being carried out in the nursery at Dhoni with special reference to the determination of:—

(1) The best method of sowing.

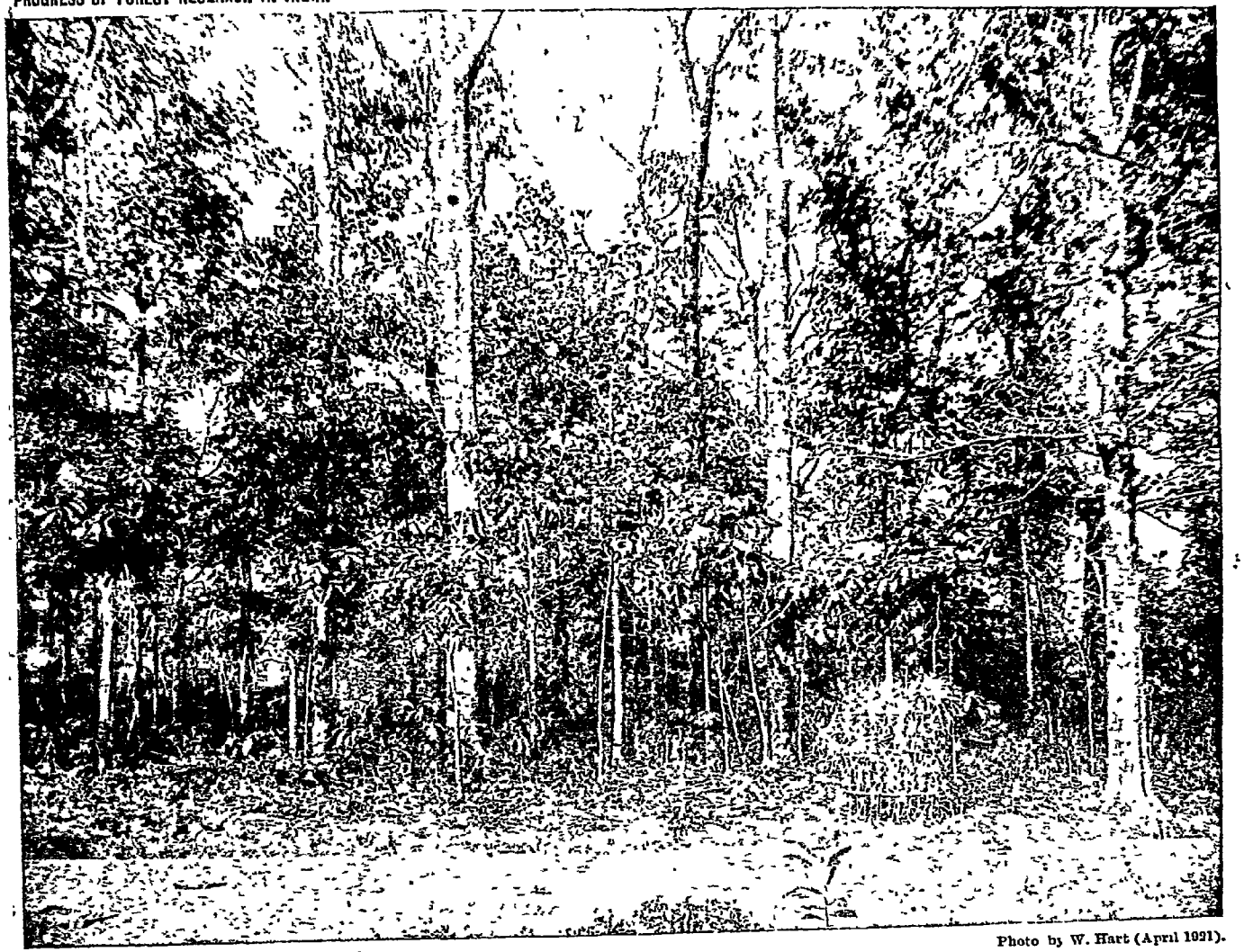


Photo by W. Hart (April 1921).

Photo.-Mech. Dept., Thomason College, Roorkee.

6 under Teak at Dhoni, Malabar

(2) The general factors relating to the time of collection of seeds such as season of sowing, age of seed, source of seed, etc.

(3) The storage of seed.

(4) Method of transplanting and at what age.

(5) Factors affecting development in early youth, such as overhead and side shelter from sun, direct rain as opposed to drip, etc.

(6) Method of stimulating germination.

In South Malabar District (Nilambur and Nedungayam, from 50 to 100 feet above mean sea level. Annual rainfall from 120″ to 140″) investigations being undertaken are:—

(*a*) To ascertain whether *Hopea parviflora* and *Artocarpus hirsuta* can be successfully introduced as an underwood for teak in the teak plantations at Nilambur and Nedungayam, and if so, at what age of the teak plantation could each of the two species be most successfully introduced.

(*b*) The best means of converting the deciduous natural forest near Pulimunda into an evergreen forest by sowing or planting.

(*c*) The introduction of box-wood species such as *Tetrameles nudiflora, Cedrela Toona, Bombax malabaricum,* etc., into the above forest.

To express the results with *Hopea* in percentage of surviving healthy plants, sowings and plantings under one year old teak showed no surviving plants at the end of a year. Sowings and plantings under teak after the first thinnings resulted in fourteen per cent. of healthy plants at the end of a year; sowings and plantings under teak after the second thinning resulted in 2·6 per cent. of healthy plants at the end of a year—or rather at the end of the following month of March.

There are no survivals of *Artocarpus* in any of the plots.

The evergreen species being tried in the Pulimunda forests this year for the second series of experiments are:—

Calophyllum tomentosum, Hardwickia pinnata, Dipterocarpus turbinatus, Dysoxylum malabaricum, Mesua ferrea, Bischofia javanica, Gluta travencorica, Artocarpus hirsuta and *Hopea parviflora.*—Details of results regarding these and the boxwood species can only be recorded in the next report.

North and South Mangalore Division. (Parappa, Malkur, Subladi, etc. Elevation from 50 to 150 feet above mean sea level. Annual rainfall from 120 to 160 inches.)

The experiments carried out in these Divisions aim at (*a*) Determining the best method of uncovering a young crop of *Hopea parviflora* both in a deciduous and in an evergreen or semi-ever-

green type of forest. Some years must elapse before any conclusive results are arrived at.

(*b*) Ascertaining the best way of inducing natural regeneration of *Hopea parviflora* in an area where *Hopea* seed-bearers exist but regeneration is absent; also to find out the best method of artificially regenerating an area apparently suitable for growing *Hopea* but where no *Hopea* seed-bearers exist.

(*c*) Determining the age at which *Hopea* seedlings can be most successfully transplanted and to what extent if any, root pruning and weeding would be beneficial.

(*d*) Investigation into the coppicing powers of *Hopea parviflora* in areas under regeneration.

(*e*) Investigating the cause and effect of good and bad seed years with reference to the more important species, deciduous and evergreen.

Burma.

On the return of Mr. Blanford from leave on the 23rd December 1920 the new post of Silviculturist was formed. During the short period of the year remaining but little actual research work could be done and the Silviculturist has been occupied in getting in touch with the work going on in some of the more important Divisions. A commencement was made by touring throughout the Tharrawaddy Division where all regeneration areas were visited and results of work in the previous rains noted. During the latter part of this tour the Silviculturist was joined by Mr. S. H. Howard, Silviculturist, Dehra Dun, who gave much valuable information on research methods. During February a short visit was made to the Burma Mines Corporation's workings at Namtu and proposals were drawn up in connection with the supply of mining timber and fuel for the mines. The existing method of working these forests under coppice with standards cannot possibly supply the Corporation's requirements *in perpetuo* and there is likely to be great difficulty in obtaining the necessary timber, more especially for the temporary mine props and lagging that are required. The only possible solution of the problem is to commence plantations on a large scale of some rapid growing but suitable timber. Eucalyptus has been suggested and will be tried. The size of the timber required is mostly about 10″ to 12″ in diameter but a certain amount of somewhat larger timber to give planks for mine lagging is also necessary.

Collection and supply of seed.—The Silviculturist has taken over the arrangements for the collection of seed required by Divisional Forest Officers when it is not available in their own Divisions, and also the supply of seed of all sorts for silvicultural or botanical work for other Departments or outside Burma. The indents from other countries, especially for bamboo seed, are increasing greatly.

Collection of statistics.—Many of the older sample plots made in the Province have been lost sight of but as these were generally made with insufficient experience of the requirements of sample plots, their loss is not greatly to be deplored. Of late years several sample plots have been made in Bhamo, Katha and Mogok Divisions by Working Plans Officers mostly in connection with In (*Dipterocarpus tuberculatus*) and there are several plots in North Toungoo Division and in Divisions in the Hlaing Circle made by the Research Officer. A number of these were made in In forest to ascertain the rate of girth increment. Several of these plots have been remeasured during the past year and show that the girth increment of In is extremely slow and averages very considerably less than 0·5 inch per annum. In Mogok the average is only about 0·2 inch. The figures have not yet been analyzed but there are a number of plots from which it will be possible to get valuable figures in the near future.

The few figures for Kanyin (*Dipterocarpus turbinatus*) received so far show that the girth increment of this species is considerably faster.

Records of all permanent sample plots are being collected in the Silviculturist's Office. The work in experimental silviculture is so urgent that until assistants are available it is doubtful if much can be done to lay out permanent sample plots for the present. Efforts will, however, be made to train a sample plot party during the coming year.

The collection of rough volume data for teak and other important species is a matter of some urgency, more especially in view of the decision to fix a yield by volume. In Tharrawaddy Division considerable data have already been obtained, in the case of teak, by the timber extraction staff, thanks to the assistance given by Mr. A. E. Elmore, Extra Assistant Conservator of Forests, in the case of other species by subordinates entrusted with the revenue marking of timber in the clear felling in regeneration areas in that Division. Wherever possible timber is measured and marked for duty at stump and the volume of timber obtained from each tree is noted down in the original list of trees marked in which also the breast height girth before felling is noted. The data given in this way are necessarily rough but will allow of the compilation of volume tables years in advance of accurate tables made by more reliable methods.

Experimental silviculture.—At present this is mainly confined to regeneration and in particular to regeneration in bamboo forests. Notes of interest have been received from Divisional Forest Officers but this report will attempt rather to summarise progress in the principal problems that confront the forest officers in this province

and to note on the special points which require early confirmation. The areas undertaken and the cost have been dealt with elsewhere.

(2) One of the chief problems has been the late, uneven germination of teak seed resulting in a small and weakly seedling in the first year. It has been proved that teak seedlings resulting from early germination can attain 4′ to 5′ in the first rains, but as a general rule teak seedlings, especially when growing in paddy, are of uneven growth and often only 2 or 3 inches high when the paddy in the taungya is reaped. The paddy undoubtedly has a considerable effect on the growth of the teak seedlings as seedlings grown without paddy, provided they are well weeded, are always stronger and more vigorous. The reason in the past has usually been that most of the teak seed has not germinated until after the paddy was sown and the roots have been choked by the paddy. Paddy is however very shallow rooted and, if the teak can get a start on the paddy, a vigorous seedling with fairly large leaves usually results. Early germination of teak seed has therefore long been a subject for experiment. The difficulty seems to be a very much greater one in Upper Burma Divisions than in Lower Burma probably because the early rain in Lower Burma is more continuous and regular. As long ago as 1874 Mr. Gamble discovered that heaping teak seeds and watering them led to early germination and this method is still found, at any rate in Lower Burma, to give very excellent results provided the seeds are sown before they actually germinate in the heaps and at a time when the rain and moisture in the air can carry on the process of germination.

(3) Of late years burying the seed for a year before sowing has been found to give excellent results in Upper Burma but experiments in this method of treatment in Lower Burma have been generally unsuccessful as the seed, unless buried in dry ground under shelter from the rain, usually gets too wet and goes bad.

(4) In Tharrawaddy Division very successful results were obtained by broadcasting teak seed on level places, as soon after the taungyas were burnt as possible, and transplanting the early germinating seedlings to stake. The resulting plants were 2′ to 3′ high at the time the paddy was reaped. It is doubtful however if this method would prove successful in Upper Burma.

(5) A most interesting method of planting teak which has led to astonishing results is the planting of root and shoot cuttings of one-year-old nursery seedlings. This method of planting has no doubt been tried by many people with fair results but the credit of showing the best method of using these "stumps" belongs to U. Po Thin. Extra Assistant Conservator of Forests, K. S. M., A. T. M., Katha Division. The "stumps" should be taken from healthy seedlings with well-developed shoots and roots. The shoot is cut off 2 inches above the collar and the root 6 inches below the collar. No special

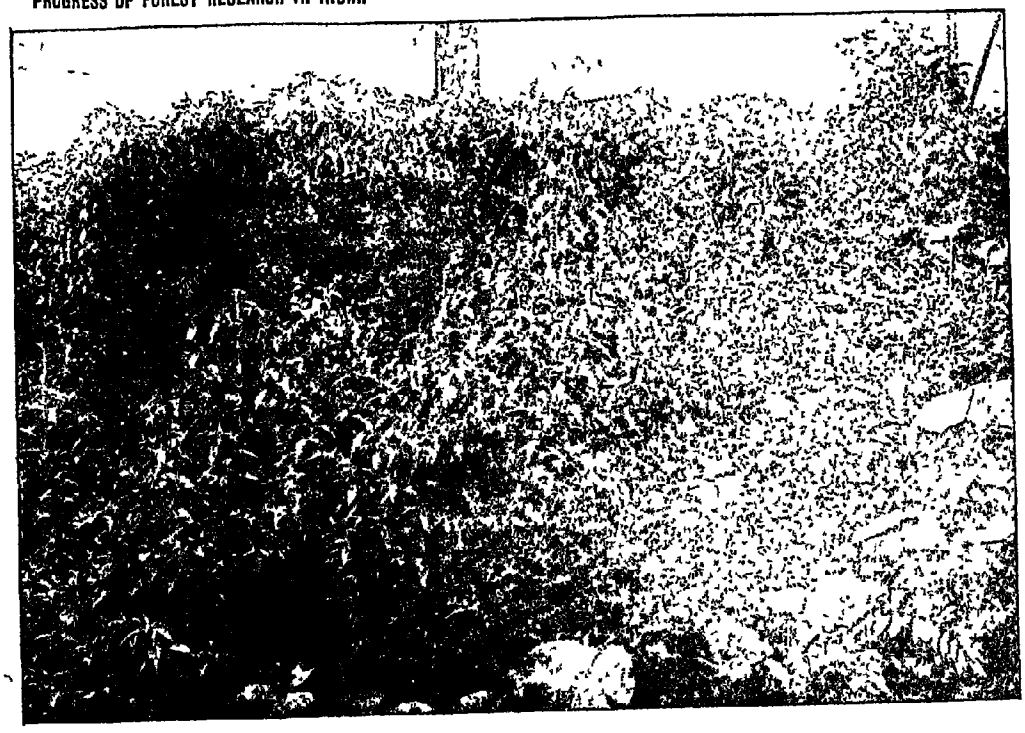




Photo by H. R. Blanford. Photo.-Mech. Dept., Thomason College, Roorkee.

A 1920 Teak Taungya in Zigon Division planted 6′ × 6′. Photographs taken 15th July, 1921. The upper photo shows area before weeding : the lower shows the same area after weeding.

Ordinarily, at any rate in teak plantations, the crop should be established after the third year and a creeper cutting and possibly unremunerative thinning in the 5th or 6th year and again between the 12th and 18th years would be all that is necessary.

	Rs.	a.	p.
Fifth year. Cleaning, creeper cutting and possibly thinning	3	0	0
Unremunerative thinning 12th to 18th year	3	0	0
TOTAL	20	12	0

In some Divisions it may not be found possible to reduce the cost of planting by taungya cutters below Rs. 12 or Re. 1 per 100 plants and the cost would then be Rs. 26-12 per acre. These rates are calculated on labour at 12 annas per day.

The above is considered an outside estimate and should be capable of very considerable reduction in the cost of weeding in the second and third year. More especially should this cost be reduced in the case of teak and faster growing species that can be established with greater ease. The above costs do not however include everything. Taxes are remitted to all taungya cutters and increase the cost of formation by Re. 1-4 per acre. Establishment and supervision charges are not included as these are annually recurring expenses and not capital cost. A small increase should also be made for such items as survey and inspection paths.

(7) One of the most promising methods of reducing the cost of weeding is the broadcast sowing of accessory species. This is analogous to the sowing of *Leucæna glauca* in the teak plantations in Java. The idea is to get up a dense crop of accessory species to assist in keeping down the weeds. The ideal mixture for a light-demander is for the accessory species to be slightly slower growing than the major species but to cover the soil rapidly. So far Binga (*Stephegyne diversifolia*) has proved by far the best for this purpose. It frequently comes in naturally in *yas* in a dense mass and it has a small seed suitable for broadcast sowing which is cheap and easy to collect. It also grows at any rate for the first 2 or 3 years a little slower than the teak in most *yas*. Hnaw (*Adina cordifolia*) has also proved very suitable for this broadcast sowing. Among others that are cheap and easy to broadcast and which have been found suitable are:—

Pyinma (*Lagerstroemia Flos-Reginae*).
Leza (*Lagerstroemia tomentosa*).
Myaukchaw (*Homalium tomentosum*).
Thitpayaung (*Nauclea excelsa*).

Of the above Pyinma germinates very readily and forms a useful stock in the event of failure of the major species. It also stands a lot of shade and can probably continue as an understorey with the more rapid growing and lighter crowned species. In teak

plantations where Binga or Hnaw have been broadcasted or have come in naturally the expense on weeding in the second year has often been more than halved and only one weeding has been found necessary.

(8) In connection with accessory species it may be mentioned that in many taungyas dense masses of Myaukngo (*Duabanga sonneratioides*) and Mau lettan (*Anthocephalus Cadamba*) have appeared from natural seed. At first these were welcomed but it has been found that they grow so fast that they rapidly suppress all other species unless thinned out heavily or cut back. The extraordinary rate of growth of these species has been shown in many places in the last year. Early in the rains when the first weedings were done in the second year plantations Myaukngo and Mau were interfering with the major species and were left. By the end of the rains they formed a dense thicket up to 18′ high completely suppressing the major species. At the same time the areas on which Myaukngo had established itself were very free of weeds and creepers and where the growth was not too dense valuable shade bearing species had undoubtedly benefited by the shelter and protection given to the soil. Considerable use can therefore be made of Myaukngo as a nurse, especially with Pyinkado (*Xylia dolabriformis*) provided care is taken to keep it well thinned and not allow it to suppress more valuable growth.

(9) Mr. Dawkins, Divisional Forest Officer, Zigon Division, has paid great attention to the question of early burning as compared with fire protection of young regeneration areas. The advantages of early burning in later stages of growth when the canopy has formed and the area is free of grass and weeds are probable, as much of the expense of fire protection can be saved but it has not yet been proved that early burning in young regeneration areas of 2 to 5 years of age is an adequate method of protection. For one thing early burning is not an easy operation. If it is to be done early enough to avoid a serious fire it must be done when the growth is still too moist for the fire to spread. This means efforts to burn small patches repeatedly and over large areas this is very difficult to do. Considerable further investigation into this question is necessary before a definite decision can be reached. It has, however, been proved that a burning of the paddy straw and weeds after the first year considerably reduces the weeds and encourages healthy shoots from the tree seedlings of the more valuable kinds. Indeed very few of the tree seedlings are killed by fire. Myaukngo, Mau, and Baing are however killed outright as are some of the more evergreen species such as Kanyin.

(10) Up to the present very little attention has been paid to nursery treatment. Nurseries, usually of a rough and ready kind, have been used for the supply of seedlings for the patching of

blanks and nurseries have frequently been used for transplanting Yemane (*Gmelina arborea*) seedlings which seem to thrive better than when seed is sown at stake. At the same time nurseries are assuming more importance in the regeneration of low-lying and swampy areas in the Plains Reserves. In Bengal, nursery treatment has received much more attention, thanks mainly to the assistance of Mr. P. T. Russell of the Cinchona Department, and considerable use is now made of nurseries for supplying transplants for taungya areas. While it is doubtful if we shall ever do much planting of such species as Pyinkado and Taukkyan which come up easily from seed and are rather difficult to transplant, planting of nursery seedlings might give better results than sowing in the case of teak, Yemane, Pyinma, Kokko (*Albizzia Lebbek*) and many other kinds by ensuring a more early establishment of the crop by rapid early growth. The question of nursery treatment therefore merits more attention and the records on the taungyas of Bengal which contains much valuable information in this respect will be of great interest to Forest Officers in Burma.

(11) The Plains forests in Lower Burma offer a different problem. Generally these forests are the few remaining pieces of the old forests which not so very long ago covered a great portion of the extensive paddy plains of Lower Burma. In some cases the forest has survived because the ground is slightly higher than the rest of the plain and was not therefore suitable for permanent cultivation. Such areas are usually fairly well drained and regeneration by the taungya method can be adopted. Many of the reserves, especially near the railway line, were however cut out of the original forests and preserved when it was seen that the original forests would rapidly disappear with the increase of cultivation. In these cases permanent cultivation extends up to the Reserve boundary and has entirely altered the natural drainage of the country. The result is that the water cannot escape rapidly from the reserve and waterlogging results. The original forest was established under quite a different condition and it is exceedingly difficult to reproduce it. Some success has been obtained in allowing villagers to plant vegetables and sugar-cane on condition that they sow or plant tree species and tend the seedlings: but much of the area is too waterlogged even for sugar-cane. A fair amount of success has been gained with Andaman Pyinma (*Lagerstroemia hypoleuca*) and Andamans Padauk (*Pterocarpus dalbergioides*), while on slightly higher ground Pyinkado and Taukkyan (*Terminalia tomentosa*) promise well. Eucalypts have been tried in Thatrawaddy and North Pegu Divisions among other places and have failed. Experimental plantations of fuel-yielding species in the Kamase Reserve in South Pegu Division have not proved a success owing to waterlogging and it has been decided to

disafforest this area. The latest method of planting attempted was to transplant nursery seedlings on beds 2′ 6″ high. Owing to heavy floods nearly all the tree seedlings planted out in 1920 were killed, and it was found that the beds had sunk to a height of only 1 foot. The bamboos planted out in 1919 have done well.

(12) *Indaing.*—No experiments were recorded during the year of any attempt at inducing natural regeneration of *In* but Mr. Shirley (Bhamo Division) reports that an experiment of clearing over young *In* regeneration proved fairly successful. An experiment of making a seed felling for *Ingyin* proved a failure as a dense mass of *thekke* grass sprang up and the weeding carried out on a small portion of the area proved very expensive. Too much cover had been removed. A further experiment in cutting only undergrowth and low cover of valueless teak is being made.

General.—The following are general notes of interest on experiments reported by Divisional Forest Officers:—

(13) *Eucalypts.*—Mr. Clifford, Southern Shan States Division, reports that the attempt to fill up gaps in coppiced areas with Eucalypts failed. Seedlings of *E. Globulus* and *citriodora* were raised in the nursery but died off before the cold weather. In view of the proposal to experiment with Eucalypts for the supply of the requirements of mine timber for the Burma Corporation at Namtu, this is disappointing. There is no doubt that the nursery treatment and transplanting of Eucalypts is a matter of considerable difficulty and it would probably be as well to depute an officer to the Nilgiris to study methods used in connection with Eucalypts there. Members of the Burma Corporation who have made enquiries in Australia say that experts there advised that there should be no difficulty in growing Eucalypts at Namtu.

Experiments with Eucalypts in Lower Burma have mostly proved a failure though some few are surviving and thriving in a fairly swampy area in one of the Plains Reserves in Tharrawaddy Division.

(14) *Evergreen species.*—The Divisional Forest Officer, South Tenasserim Division (Mr. Mathews), reports that he is sowing several of the more important evergreen species in taungya. Experiments with regard to the regeneration of species growing in the heavy evergreen forests of Tavoy and Mergui is of great importance in view of the fact that these forests are among the best stocked and therefore most suited to commercial exploitation on a large scale in the Province. The result of these experiments must be awaited.

(15) *Reafforestation.*—Efforts are being made in the Bhamo Kachin Hills to reclaim land which, owing to repeated taungya cutting on a short rotation, has become devoid of all growth except

bracken fern and is now unfit even for temporary cultivation. An attempt is also being made to persuade the Kachins to plant rapid-growing species in their taungyas to reclothe the slopes with forest growth and thus to prevent further areas from being ruined.

Mr. Shirley writes as follows:—

"The experimental sowings of Maibu (*Alnus nepalensis*) were not very successful so far as can be seen at present, but the seedlings will probably come up again during the rains. They were mostly killed back by frost in the cold weather.

The seed was collected too late (April) and many of the cones were probably empty of seed. The Maibu does better where no weeding is done as the bracken protects it to a certain extent from frost, though the danger from fire is of course increased.

So far as can be seen sowing in lines in shallow pits gives better results than broadcast sowing though it is, of course, much harder to find the seedlings under the latter system. It is undoubtedly better to clean the seed and throw away the cones.

Silver Oak (*Grevillea robusta*) has come up well at Sinlum (6,000′) Lepykha (6,000′) and Lweje (3,500′).

Ngu (*Cassia Fistula*) came up fairly well at Lweje (3,500′) and a few Taungdama (*Cedrela Toona*) are also alive.

Other species Hnaw, Yemane, Baing (*Tetrameles nudiflora*) and Yedema (*Cedrela species*) tried at Sinlum, Lepykka and Lweje all failed.

(16) *Miscellaneous.*—Plantations of Mulberry for silkworms at Sehé and Namtu in the Mandalay Division have proved successful.

From Mandalay and Meiktila Divisions come reports of the entire failure of plantations of *Cassia Fistula* and *auriculata*. These were made with a view to the supply of bark for tanning. The sites for the plantations seem to have been badly chosen.

The Divisional Forest Officer, Lower Chindwin, reports on some experimental plots made with a view to clearing out *Strobilanthes* cheaply and regenerating teak. He also reports on some experiments made in regenerating Cutch. A certain amount of success was obtained by dibbling cutch seed 3′ × 3′ but otherwise the experiments have proved nothing and do not seem to have been given much supervision. The Conservator remarks that he can see no use in sporadic unregulated experiments.

5. *Publications.*—There were no publications on silvicultural matters during the year. Arrangements have been made for the issue of information of interest to the Burma Forest Officer in the form of Bulletins. The first three numbers of this series are already in the press. The series will include notes on other subjects such as Economics, Botany, Zoology, etc., a separate series being kept for each subject.

CHAPTER III.

Forest Botany.

Central Institute.

The Forest Botanist was absent on leave, with the exception of the last three months only of the period under report. The work of the branch, in consequence, was chiefly confined to routine duties but some progress was made with research work under the items noted below:—

Ecology of Sal.—The result of the sowings made in June 1920 in the local Dehra Dun forests has supported the results obtained in previous years, *viz.*, that sowings in small clearings are more successful than sowings under partial or complete overhead cover. The development of the older seedlings, also, has now clearly demonstrated the fact that, by artificial sowings in these clearings, seedlings can be raised in the local forests with little or no dying back and which attain a height of 6 feet in 6-7 years. A factor which has assumed some importance during the year with reference to the development of these older seedlings is the damage done by rats and porcupines which destroy a number of vigorous young seedlings by eating through the sappy tap-roots. It is believed that this kind of damage will be relatively unimportant when work is carried out on a large scale and the supply of vigorous young seedlings is greatly increased. A very similar state of things has been noticed in the case of damage to the seed. In bad seed years when very little seed is available in the local forests, porcupines and other animals destroy a large proportion of the seed in the artificially sown areas, whereas in good seed years practically no damage is done.

Based on the experimental work carried out under this head in recent years a group-*cum*-strip system of regeneration, which was outlined in a paper by the Forest Botanist in the *Indian Forester*, XLV, 1919, pp. 119-132, has been suggested for certain types of sal forest. Full details were necessarily omitted from this preliminary sketch and there has been some misunderstanding in consequence regarding the scope of the work which has already been done and of that which it is suggested should now be undertaken. An article dealing with the various criticisms which have been recently published regarding the suggested system was sent to the *Indian Forester* for publication towards the close of the year and the final proof of the Forest Record has been passed which contains the detailed account of the experimental work carried out up to date. What is now desired is that the work initiated by the Forest Botanist, working intensively on a small

scale, should be carried a stage further by getting local forest officers to test the suggested system on a larger scale than the Forest Botanist has been able to do. There is no doubt that work carried out on a large scale, in different localities, by forest officers themselves is most likely to carry the conviction which is necessary for the adoption and successful working of a practical system of forest management. On the other hand, by carrying out the preliminary work on a small scale, unnecessary expense and waste of labour and time are prevented.

It is satisfactory to note that the Conservator of Working Plans in the United Provinces has now agreed to test the proposed system experimentally on a large scale. The main principle which has emerged from the work done up to date on this subject is that, in order to accelerate the growth and establishment of sal seedlings, it is necessary to secure, as far as possible, the most favourable conditions of soil-moisture and soil-aeration throughout the year, and that these conditions can often be greatly improved by making small clearings, with a suitable arrangement and degree of side shade, and by raising the seedlings in these open areas instead of under the shade of the forest. In this way favourable conditions of moisture and soil-aeration can be secured, dense and vigorous weed growth is not produced, frost damage is prevented and the soil surface does not become injuriously hardened or compacted. Whatever the precise systems of management may be which are ultimately adopted to suit the local conditions prevailing in the various types of sal forest, it is probable that increasing attention will be paid to the importance of this principle in the Indian Working Plans of the future. Local officers in the United Provinces have initiated large scale experiments during the year for the purpose of determining the best way of applying the principle in question to sal managed under the uniform method of treatment.

Ecology of Teak.—In 1916 the Forest Botanist published the results of experiments which showed that clear felling had a decidedly favourable effect on the germination of the seed and on the development of the seedlings of teak (*Indian Forester* XLII, pp. 51-57). During the year this matter has again received attention in an interesting article by the Hon. J. W. Best in the *Indian Forester* XLVI, pp. 411-415, where the opinion is expressed with reference to teak plantations in Berar that "clear felling in strips is likely to lead to the best results." There is little doubt that the principles which have been found to apply to sal will also be found to apply to a considerable extent to teak, and it is believed that there is considerable scope now in India for ecologists working in co-operation with forest officers in devising improved methods of treatment for many of our important species,

the seedling growth of which is at present often unsatisfactory and very slow.

Root disease of sal caused by *Polyporus shoreae*.—In co-operation with Dr. Shaw of Pusa a number of healthy sal saplings at Dehra Dun were inoculated with *Polyporus shoreae* in 1916 by the Assistant Botanist, Mr. Abdul Hafiz Khan. During the year under report, several of these saplings were dug up and examined. The results so far obtained indicate that, while the fungus is unable to attack a healthy unwounded root, successful inoculations were invariably obtained when the mycelium was placed in contact with the wood in the interior of the root by means of a wound. It is interesting to note that Mr. W. E. Hiley, in his recent work on the larch in the United Kingdom, has come to the conclusion that good soil aeration is of great importance for that species and that the fungus *Fomes annosus* gains an entrance into this tree through roots which have been killed by bad soil aeration (*Fungal Diseases of the Common Larch* Oxford, 1919, p. 184). It is probable that the most effective means of controlling troublesome root diseases, such as that of the sal mentioned above and that of *Dalbergia Sissoo* caused by *Fomes lucidus*, will consist in improved methods of treatment which will ensure a better condition of water-supply and soil aeration.

Spike Disease of Sandal.—In the annual report for 1917-18 the Forest Botanist drew attention to a line of inquiry which seemed to promise good results. There is a frequent connection between spike, both in *Zizyphus* and Sandal, and the widespread death of twigs caused by weak parasitic fungi and it is possible that spike is caused by a very dilute solution of an enzyme excreted by these fungi which may only be able to enter the main water and sap currents in the plant when the damage is unusually severe or prolonged, when the plant has been weakened by other factors or under other special conditions. Such a hypothesis would harmonize with practically all the theories which have as yet been advanced regarding this disease and it has received considerable support from the recent work of Mr. W. B. Brierley on *Botrytis cinerea* in England. While on leave in England recently, the Forest Botanist discussed this question with one of the leading mycologists at home who expressed the opinion that "a careful study of the enzymic relations of common tree fungi would I think be invaluable and might give the key to the whole problem." With the early addition of a Mycologist and a Biological Chemist to the staff of the Forest Research Institute it is hoped that this line of research will now be energetically developed.

Systematic Botany.—During the year 22 specimens were identified at Dehra Dun for inquirers and the Forest Botanist while on

leave studied the material in the Kew herbarium of the genus *Tamarix*. Mr. H. H. Haines is working at the Forest Flora of Bihar and Orissa, Mr. R. N. Parker is revising his Forest Flora for the Punjab, Rai Bahadur Kanjilal is working at the Forest Flora of Assam, Mr. C. E. Parkinson has completed his draft of the Forest Flora of the Andamans and Descriptive Lists are in preparation for the United Provinces by Messrs. A. E. Osmaston and P. C. Kanjilal.

Herbarium.—666 sheets were added to the herbarium during the year, the chief contributors being Messrs. A. E. Osmaston, R. N. Parker and W. J. Lambert.

Library.—19 volumes exclusive of periodicals were added.

Tours.—The Forest Botanist visited Pusa in February and gave an address on the Physiology of Disease at the Conference of Mycologists, which was also attended by the Assistant Botanist Mr. Abdul Hafiz Khan. The Assistant Systematic Botanist Mr. B. L. Gupta attended the Indian Science Congress in Calcutta in January 1921.

Indents.—A large number of indents for seeds were complied with and they were despatched to various places in India and to England, France, the United States, Egypt, Ceylon, Palestine, Abyssinia and Mesopotamia.

Burma.

An officer on special duty examined the oaks and chestnuts near Maymyo and in the Northern Shan States with reference to their usefulness as a source of tannin. He found several species which may be new and further specimens will be collected.

Many of the planted Padauk trees (*Pterocarpus indicus*) in Lower Burma have died recently, and it is believed that their death was due to a root fungus. Specimens were sent to Dehra Dun.

A few specimens were collected and named, but nothing was done in the Maymyo Herbarium during the year. A trained Superintendent was engaged in England to take charge of the Botanical Garden at Maymyo and of the Government House gardens at Mandalay and Rangoon: he took over charge before the end of the year.

Work in the Botanical Garden at Maymyo continued throughout the year. The results are already very good and, as noted last year, the Forest Department and the general public are very greatly indebted to Lady Cuffe for the splendid work she has done there.

CHAPTER IV.

Forest Economy.

Central Institute.

The year under report saw a definite step forward in the expansion of the Economic Branch. Up to the commencement of 1920, the staff consisted of the Forest Economist and his Assistant, the Tan Specialist, a Museum Assistant, and an office establishment barely sufficient to carry on the work. Since then the Secretary of State for India has sanctioned the addition of six new sections, namely:—Wood Technology, Seasoning, Timber Testing, Wood Preservation, Minor Forest Products, and Paper Pulp, and officers have been appointed to all sections except to the first and fourth. A number of Upper and Lower Grade assistants' posts have also been sanctioned for each section, which will gradually be filled up as each section develops.

The Forest Economist returned from deputation to America, Canada and England in August 1920 and at about the same time the experimental machinery purchased in the above countries arrived in Dehra Dun. A set of wood working machinery was purchased in India and was also received during the year.

In consequence of the above new development, the staff was chiefly engaged on organisation work in the several sections and little could be done with respect to new investigation, while much of their time was taken up in checking the experimental plant received and in outlining projects of work to be taken up in future.

1. *Section of Wood Technology.*

Until a wood technologist is appointed no work is possible on the purely technical side of this subject, such as the preparation of microtome slides to facilitate identification, and the examination of the physical properties of Indian timbers. The work was confined to finding new markets for timber and in this connection an extensive enquiry is in progress at this Institute, working in conjunction with the Utilization Circle, Bareilly, United Provinces, and a large oil factory in Madras, to test certain timbers for the manufacture of oil casks. Another enquiry is being carried out, also in conjunction with Bareilly and a well known English firm, to test Indian timbers for cotton bobbins. Similar enquiries are in hand in respect of whiskey kegs, boot lasts, tool handles and other wooden articles.

For the last ten or more years the publication of a series of bulletins has been in progress, each dealing with one of the more important Indian timbers. Up to date twenty such notes have

been published while three more are in the Press, one is under compilation and information on six others is being collected.

A complete experimental three-ply machine was purchased in America which has since been received in Dehra, and will be erected in the new laboratories. The scope for three-ply furniture and ornamental panelling is very considerable in India and as soon as the machines are working it is proposed to test our more ornamental timbers to determine their qualities and appearance when cut on a rotary section.

A saw-mill to feed the seasoning kilns and wood workshops has also been purchased, which will be one of the first plants to be erected on the new site.

A large number of enquiries from firms were dealt with, covering a variety of uses for which timber is used. A definite start was also made in collecting and publishing price lists of various Indian timbers.

2. *Section of Seasoning.*

Though extensive experiments to ascertain the best method of naturally seasoning timber have been in progress for some years, a separate section of seasoning was not started until a specialist from the United States Government Forest Products Laboratories, Madison, Wisc., was appointed last autumn. Soon after Mr. Sweet's arrival he carried out the final inspection of the seasoning experiments in Bengal and the Central Provinces, the results of which will be published in the near future. The development of this section is of the greatest importance and will undoubtedly lead to results of far-reaching importance. The apparatus for the four blower and three steam spray drying kilns is now coming to hand and it is hoped to erect the kilns in the cold weather.

3. *Section of Timber Testing.*

A new section of Timber Testing was brought into being during the year, and the services were secured of the Chief of that section in the Canadian Government Forest Laboratories, at the McGill University, Montreal. As some of the testing machines purchased in England and America have reached Dehra Dun, Major Seaman at once set to work to assemble the 100,000 lb., 30,000 lb., 10,000 lb., universal machines and the 250 lb., impact machine and it is hoped to get to work on the preliminary testing operations at once. One of the first series of tests to be carried out is on redwood of spruce to determine its value for sleepers after impregnation. A complete project according to which tests on the more important Indian timbers will be carried out is under preparation. The importance of this work cannot be over-estimated.

4. *Section of Wood Preservation.*

A complete experimental antiseptic pressure plant was received from England, but was not erected as the Forest Economist had not time to spare owing to the heavy calls made on his time in connection with the rapid expansion of his branch. The appointment of a Wood Preservation Specialist is sanctioned but a suitable officer has not yet been procured. The question of developing this section is of great urgency as the railways are now keenly interested in the matter, one having actually erected a treating plant while three others comtemplate doing so.

The experimental sleepers laid from 7 to 10 years ago in open lines and treated by four different methods were inspected. Those laid in the lines 10 years ago and treated by the Powell process, show that *Terminalia tomentosa*, (Sain) are, with few exceptions, doing remarkably well. *Pinus longifolia* and *Pinus excelsa* are also still doing well in the dry localities, moderately so in damp, and have all been rejected after from 9 to 10 years service when placed in very damp localities. The two Dipterocarps, In and Kanyin (*D. tuberculatus and turbinatus*) have lasted 10 years, the cause of rejection being deterioration under the rail seat and around the spike hole. Had both the Pines and Dipterocarps been laid with bearing plates they would have lasted 2 or 3 years longer, bringing their life up to that of deodar or sal in similar localities. In the other experiments treatment with creosote and earth oil, introduced in fairly large quantities, have given better results than either treatment with a small quantity of high grade oil or treatment with chloride of zinc and creosote.

5. *Section of Minor Forest Products.*

At the end of the year an Imperial Forest Officer was appointed to this section, and it may now confidently be hoped that our knowledge of this subject will expand rapidly.

The question of utilising the gum-oleo-resin of *Boswellia serrata* was advanced a step further by the publication of Dr. Fowler's valuable note on the work he had carried out at the Indian Institute of Science, Bangalore. His process differs from that advocated by Mr. Puran Singh in that alcohol is not used as a solvent. The Gwalior State are about to erect a plant working by the solvent process, the results of which will be watched with great interest, while a Bombay company are applying for a lease in that Presidency; so that there is every hope of this industry developing in the near future.

The steam distillation of Rosha Grass Oil is now carried on as a commercial undertaking and is being carried out successfully by a company in the Central Provinces.

The investigation into the manufacture of charcoal briquettes has been continued. The points to be settled are whether charcoal can be ground without undue danger of spontaneous combustion but with the pressure necessary to produce a satisfactory briquette. The pressure question is shortly to be taken up at Dehra Dun, while a parallel line of enquiry is being followed by sending 500 lbs. of charcoal and 100 lbs. of binding material to a well known American briquetting firm, with which to carry out tests.

6. *Section of Paper Pulp.*

Mr. Raitt, who took over charge of this Section last December, was previous to his joining this Institute as a whole-time officer, on deputation in England in connection with the design and manufacture of an up-to-date experimental paper and pulp plant, which it is hoped will soon arrive at Dehra. Since the armistice the question of utilizing bamboo for paper pulp has received much attention both in this country and at home, with the result that one bamboo pulp factory has been erected and is running near Calcutta and another in Burma, while several similar schemes are well advanced in Burma and elsewhere. The preliminary work of carrying out new surveys of possible bamboo areas in Bihar and Orissa and Madras was undertaken during the year, while the officer in charge also paid a visit to Burma in connection with a grass pulp scheme.

As soon as the experimental pulp and paper machines are erected it is proposed to carry out a complete series of tests on Savannah grasses.

7. *Section of Tans.*

Mr. Pilgrim continued his investigations into the tan values of the chestnuts and oaks of the Shan States and of certain Dipterocarps and other kinds which occur locally. So far the results are extremely encouraging but it has not yet been possible to complete the survey by forest officers on which the possibility of utilisation on a commercial scale eventually depends.

The report of the above officer on the "Tanstuffs of the Sunderbans Forest Division" the investigations of which had been undertaken in the previous year was published by the Department of Industries, Bengal. In this case also the departmental survey has not yet been completed.

8. *Sub-section of Wood Working.*

To test the properties of timber in so far as they lend themselves to be worked up for turnery, furniture or carving, etc., a sub-section of wood working was formed towards the end of the year and a skilled wood worker appointed in charge. Not only

will these shops carry out investigation as detailed above but they will also attend to the requirements of other sections, such as preparing specimens for timber testing and the museums, making specimen boxes, office furniture, etc.

The number of enquiries on the strength, seasoning qualities and treatment of various timbers, substitutes for imported timbers, on pulp, tans, gums, resins, oils and other minor forest products, increases very materially from year to year. Formerly, when there was only a Forest Economist and his assistant to deal with such an enquiry, the answers given were often not satisfactory; with an enlarged staff of specialists, matters are now on a somewhat sounder footing, but it will not be until the laboratories and workshops are equipped and in full working that the entire benefit can be derived from this branch of the Institute.

A number of interesting exhibits, chiefly manufactured articles obtained from the Empire Forest Exhibition held in London, were added to the Wood Museums, while additions were also made to the wood collections and Minor Products Museum.

Punjab.

Seasoning of timber.—In the Kangra Division the Ohi (*Albizzia stipulata*) timber seasoning experiment undertaken at the request of the Forest Economist is still in progress.

Some 48 pieces of Bakain (*Melia azédarach*) scantlings already under experiment were sent to the Forest Economist at the Research Institute from Changa Manga during the year.

In the Jallo Resin and Turpentine Factory experiments in the closer regulation of distillation by means of the refractive index and investigation into the keeping qualities of Jallo Turpentine of grades I and II have been continued. The manager of the factory has also been carrying out an investigation as regards the colour of resin with a view to the production of a paler rosin which will command a better market.

Bihar and Orissa.

Seasoning Experiments.—The final inspection of the seasoning experiments on Jamun (*Eugenia Jambolana*) and Rohen (*Soymida febrifuga*), which were commenced at Sambalpur in October, 1918, have been carried out and the results will be published in the Research Institute publication on natural seasoning now in course of preparation.

Charcoal experiments.—These are still in progress. Conclusions up to date are as follows:—

(1) The ordinary paraboloidal shaped kiln of a diameter of about 15 or 16 feet gives the best results as the burning is easily controlled and the quality of charcoal produced is good.

(2) Kilns of a larger diameter than 15 or 16 feet are much more difficult to control, are disliked by the local burners on account of their size and are no more economical to burn than the smaller kilns.

(3) Lighting from the top gives better results than lighting from the bottom as the burning proceeds more regularly.

(4) A kiln covering of dry or slightly moist earth is superior to a covering of mud plaster as (*a*) cracks are not formed, (*b*) the kiln can be more easily rammed as it settles, and (*c*) most important of all, it entails the use of the minimum quantity of *water*. The percentage yield of charcoal is the same. (No experience has yet been gained of burning dry covered kilns in a wind. Possibly they will burn too rapidly and the yield will be smaller).

(5) Permanent paraboloidal shaped kilns of sundried bricks have proved a comparative failure as (*a*) the initial cost is high, (*b*) burning is difficult to control (*c*) and the extraction of the charcoal is difficult and expensive. Actually the outturn of charcoal from permanent kilns has been poor in quantity and quality.

(6) Charcoal produced from green wood is lighter and smaller than that produced from dry wood. The volume percentage of outturn is the same.

(7) It is not economical to split up wood into billets of regular size to obtain closer stacking as there is little gain in volume percentage and large sized charcoal fetches the best price.

(8) The average percentage of outturn by volume of 120 tons of sal charcoal was 40 per cent. The average is steadily rising and for the last 3 kilns burnt was 50·6. Figures for percentage of outturn by weight are not available as the weighing machine was found to be unreliable.

(9) The average cost of producing 120 tons charcoal and transporting it to the railway with a lead of 7 miles has been 11 annas per maund. For the last three tons, the work being very strictly supervised, the average was only 0-5-8 per maund. These figures exclude overhead charges which would not however amount to much.

(10) Female labour is cheaper and better than male labour for the actual work of constructing and burning the kilns.

(11) The health of labour engaged continuously on the work of burning and extraction suffers considerably. It has

thus been found necessary regularly to interchange the various tasks.

(12) No definite results have yet been obtained in producing charcoal from species other than sal except in the case of *Eugenia Jambolana* which gives a good hard charcoal and which can be burnt in the same kiln as sal as the rate of combustion is the same.

Bengal.

The problem as to the best means of utilising as fully as possible all the produce of a fifty acre clear felling coupe of sal mixed with its usual associates and a considerable underwood of miscellaneous evergreen species was investigated at Sukna, Kurseong Divisions during the year. The coupe had to be cleared by the beginning of May in order to be sown up with sal and field crops.

The Darjeeling-Himalayan Railway Company were approached and they considered that the amount of timber and fuel to be transported justified them in running a siding of about half a mile into the coupe. The Forest Department provided the necessary sleepers free, the Railway found the rest of the material and bore the construction charges. Felling and dressing of timber and stacking of fuel was done by contractors under the Forest Department.

All sal timber that was fit to cut into really good logs *i.e.*, straight lengths of 20 ft. and over was so converted and dragged to the siding. Logs of any girth over 4 ft. of this length are too heavy for the local carts to manage, while shortening the length reduces the value per c.ft. very seriously, so a donkey engine was rigged up as a skidder which dragged the logs from all over the area by wire rope to the siding and also loaded them into the railway trucks. This timber was then taken to the big depôt at Siliguri, the junction of the Darjeeling narrow gauge railway with the Eastern Bengal Railway metre gauge line, and sold there.

Sal unfit to give long logs was sawn by Nepalese sawyers into B. G. and M. G. special sleepers in fulfilment of a large order; the rates paid for special sleepers are considerably higher per c.ft. than those for standard sleepers.

There is a good demand for $\frac{1}{2}$ inch planking of most of the other species for local use as tea chests and a small saw mill was under construction to use this material but did not actually start work during the year. A considerable quantity of Simul and other logs however were collected beside the saw which has since got to work and cuts about 2,000 square ft. of $\frac{1}{2}$ inch planking daily. The rest of the soft wood timber was sawn by hand into $\frac{1}{2}$ inch planks by sawyers employed by local tea gardens. Tops of sal and other species and most of the underwood was cut into stacked firewood and taken by local tea gardens as engine firewood. It

was also sold in small quantities to bazaar firewood dealers, and a new trade was opened in firewood by train to places in the hills, both for domestic use and for hill tea gardens. It was found cheaper to get this firewood from 20 miles away by train than to cut in the hill forests within 3 or 4 miles of the garden. It is expected that this trade will expand with the saw in full working order next season.

Assam.

The increasing value of 'Agar', a deposit only found in the wood of *Aquilaria Agollocha,* has led to experiments being initiated with a view to inducing the formation of the product in various forms of wounds, borings, etc.

Burma.

The remarks made about Burma in Chapter IV of the Progress Report for 1919-20 can, with a few additions, be held to apply to the year under report. A good deal of work has been done at Rangoon, but most of it is of a preparatory nature, and it would be premature at present to attempt to go into any great detail as to the developments in economic research which are likely to take place in the near future.

Proposals for timber research in Burma are taking the form of a sawmill, workshop and laboratory in the Government Timber Depôt, Rangoon. A good deal of the machinery has been purchased, but up to the present construction had been limited to (1) a temporary sawmill, (2) Office building and (3) Dry Kilns.

Mr. L. V. Teesdale, Timber Seasoning Expert from the Madison Laboratory, U. S. A., arrived in Burma in September 1920, but it was not until after the close of the year under report that a start could be made with actual construction of the experimental dry kilns, consisting of a battery of three chambers of the Tiemann type. Within a few months it is hoped that construction will be started on the permanent sawmill and the workshop.

One of the most urgent needs of the Province is an *economic survey* with a view to ascertaining the supplies available of various timbers. A few well known timbers such as Pyinkado (*Xylia dolabriformis*), Taukkyan (*Terminalia tomentosa*), In (*Dipterocarpus tuberculatus*), Kanyin (*Dipterocarpus turbinatus*) etc. are so widely distributed and are known to exist in such large quantities that there is no immediate fear of over-exploitation. But with a number of other species the case is very different. Their distribution is more localised and diffused. It is a matter of difficulty to extract any considerable quantity for experimental sale and it is impossible to say on what scale extraction can safely be conducted without risk of over cutting. Under this head may be

mentioned Hnaw (*Adina cordifolia*), Thitkado (*Cedrela Toona*), Thitka (*Penatace burmanica*) and Tamalan (*Dalbergia Oliveri*). Some enquiries have already been started but progress in a general economic survey must naturally be extremely slow until the staff of officers for general duty and for research work in Burma has been very much strengthened. The time of the Conservator, Utilization Circle, is already so completely taken up with the multifarious duties which have devolved upon him that he has not been able to give much personal attention to the subject.

A very useful publication under the title of "A Handbook of the Forest Products of Burma" by Mr. Alexander Rodger, O.B.E., I.F.S., was published during the year by the Superintendent, Government Printing, Burma. The book contains a great deal of very useful information with regard to Burma timbers and other forest products.

Central Provinces.

Seasoning of Timber.—The seasoning experiments carried out under the direction of the Research Institute have now been completed and it is expected the results will be published shortly.

In connection with the determination of the practicability or otherwise of seasoning Allapilli teak by girdling, 133 teak trees were girdled in November 1918 of which 51 trees were felled in November 1920 and 5 in March 1921. The results so far obtained show that (*a*) even after 2 years and 4 months from girdling the timber at the centre of the log is still unseasoned and (*b*) the tendency to splitting and shattering on felling is such that girdling cannot be adopted as a practical method of seasoning in Allapilli as the loss thereby caused is enormous.

Suitability of timbers.—One hundred scantlings of log-seasoned Karai (*Saccopetalum tomentosum*) were sold at a cheap rate to a Bombay firm for trial in the form of billiard cues in March 1921. The firm will be asked later whether the cues made from them have proved satisfactory.

Lac experiments.—Lac experimental work on *Schleichera trijuga* (Kusum). It has been decided to introduce departmental lac work in South Raipur but as existing contracts have not yet expired, only preparatory measures have so far been possible. A casual inspection of the Kusum trees of this division growing in mixed and usually thick forest shows them to be tall, wide-branching trees and by no means resembling the low crowned, much-branched, gooseberry-bush-like typical Kusum tree on which lac is usually grown. Their form is such that it is physically impossible for any man to climb anywhere near to the tender twigs on which alone lac will grow. It is obvious therefore that the infection and subsequent

collection of lac from such trees would be difficult and hazardous. A number of trees have therefore been completely pollarded, the point of pollarding being dictated not so much by scientific principles as by the physical incapacity of even the most expert of jungle tribes to climb more than a certain distance along the wide spreading branches. Usually, however, branches were cut above and not below a fork. The time of the year for such pollarding had to be decided on theory only. It is generally believed that trees in this province have a period of rest in the cold weather (January-February) and this period was selected. As however lac is a bivoltine insect two pollardings are required each year, one in preparation for each brood. The cold weather pollarding is assumed to prepare the trees for the next cold weather infection about twelve months later. The June-July infection remains; and it was decided to pollard in July-August in preparation for this, for the following reasons. Observations in connection with the study of lac point to the fact that the growing season of trees in India (*i.e.*, the period of active metabolism) which commences usually in the hot weather and dies away sometime in the autumn, is divided by a period of almost complete cessation during the rains, induced firstly by the reduction of osmotic pressure of the sap to zero by the water-logging of the soil so that the sap cannot rise in the trees, and partly to the reduction of transpiration due to the water vapour saturation of the atmosphere. Though this theory was not proved, it was assumed, and trees were pollarded in July-August for infection with lac about 12 months later in June-July.

One hundred and thirty Kusum trees were completely pollarded in August 1920. It is uncertain when shoots first appeared but in February at each pollarding point there was a dense mass of shoots averaging 1' long and 2" girth at the base with a maximum of 3' long by 4" basal girth. One such tree at Gattasilli was pollarded in August 1920. It will undergo another period of growth in the hot weather 1921 before it is infected with lac. One curious result of this pollarding was noted. Pollarded trees retained their leaves fully one month longer than neighbouring unpollarded trees. By a mistake in the interpretation of orders, about 10 of the above trees were not completely pollarded and about a dozen vertical branches were left on each. These trees failed to produce pollard shoots and it would appear that all the nourishment of the tree had passed into these dozen branches left.

About 500 Kusum trees were pollarded similarly in February-March 1921. March is a little late as this year some of the trees had already begun to produce new leaves and flowers. In early April many of these trees were already sending pollard shoots. In the case of those trees were pollarded they were also freed [illegible] by cutting adjacent trees, a procedure shown to be



Photo.-Mech. Dept., Thomason College, Roorkee.

Kusum tree pollarded in August 1920,
photographed in March 1921.



Kusum tree pollarded in February 1921
and photographed the same day.

necessary by the results of the work in the previous rains. A photograph of a tree pollarded in February and photographed on the same day is shown at Plate VI.

Bombay.

Fibre.—Tali Palm fibre obtained from the leaf stalks was sent to—

(1) The Ganges Rope Co., Calcutta.
(2) The Western India Rope Co., Bombay.
(3) The Fibre Expert to the Government of Eastern Bengal and Assam, Dacca;

Report from (1) is as follows:—

"The Tali fibre sent to us for experimental purpose is of no use for rope making. The fibre is very brittle and cannot be softened even after batching the fibre for six months. We cannot say what other utility it has."

Reports from (2) and (3) are awaited.

CHAPTER V.

Forest Zoology.

Central Institute.

Insects of the Sal:—*Borers.*—In the area of the epidemic occurrence of *Hoplocerambyx spinicornis* in Thano forest, Dehra Dun, observations were continued on the plan of previous years, involving enumerations and plane-table surveys. Particular attention was paid to the effects of edaphic and climatic conditions on the incidence of the borer, which is now correlated with annual rainfall. The recognition of a connection between the periodic abundance of the borer, the resistance of the host-tree to attack, and rainfall during the flight period of the beetle has materially altered existing conceptions of the economic status of the pest. It is now apparent that in a series of years of high rainfall the increase of the borer is favoured and the resistance of the host-tree is lowered; in years of low rainfall the reverse effect occurs. If the monsoon fails during the course of a borer epidemic the proportion of trees fatally attacked is reduced (in spite of the relatively increased incidence of the borer) to such an extent that the pest receives a marked check. Control measures based on these results have been formulated and put into practice during the 1920-21 season, the first result being to reduce the yield of borer-infested timber to a degree much below that of any year since the detection of the epidemic in 1916. It is anticipated that, given a valuation of the growing stock and its increment, a safety-limit expressed in deaths per acre and a safety-period for control operations can be determined. A note on the

connection of *Hoplocerambyx* with the dying-off of sal was published in the *Indian Forester* for February 1921, pp. 69-76.

In tours carried out in Singhbhum and Porahat divisions, Bihar and Orissa, it was determined that *Hoplocerambyx* is rare or absent in dry and hill type sal forests, and that it is usually a secondary effect of *Polyporus shoreæ* in the moist and valley type sal, a condition suspected some years before in the Bengal Duars forests. The frequent mortality of sal without the assistance of borer attack leads one to consider that borers of the type of *Hoplocerambyx* are essentially secondary factors, which, however, under epidemic conditions may determine the death or survival of a weakened tree.

Further insectary records of the development of *Aeolesthes holosericea*, *Xylotrechus smei*, *Platypus* spp., *Diapus* sp., and *Xyleborus* spp. have contributed to the establishment of the economic status of these species, and revealed the extent to which their prevalence is affected by climber-cuttings and girdling or felling without removal of inferior species.

Other Pests.—The seed-weevil, which has been named *Calandra shoreæ* has been found to have a wide distribution and a variety of dipterocarp host-plants.

Insects of the Teak.—Work on the beehole borer of teak has been in abeyance pending the appointment of a forest entomologist to continue the collection of statistical data. Further insectary records of the minor sapwood borers and the shot-hole beetles have been obtained.

Miscellaneous Pests.—During the period under report 125 consignments of specimens (including 903 insects) were received from enquirers for investigation. A total of 910 specimens of timbers was received from divisional seasoning depôts for examination of the borer fauna.

Borers of Miscellaneous Timbers.—Of the subsidiary investigations the most important is that aimed at the determination of the borer fauna of timbers seasoned by various natural processes. Some 8,500 specimens have been bred out and are in process of classification and identification. It has been found possible to grade boring insects into classes according to their ability to attack (1) the living tree, (2) the girdled tree, (3) the felled log, and (4) converted timber. The recognition of the first and last classes, particularly, permits a correct appreciation of the success or failure of the natural methods of seasoning. Field-work in this connection was carried out in the Dun forests and in Bihar and Orissa.

A short survey was made in the Sunderbans, Bengal, of the borer fauna of swamp, slump and cyclone-killed trees and drift timber to obtain evidence on the survival or destruction of boring insects by immersion in brackish and salt-water.

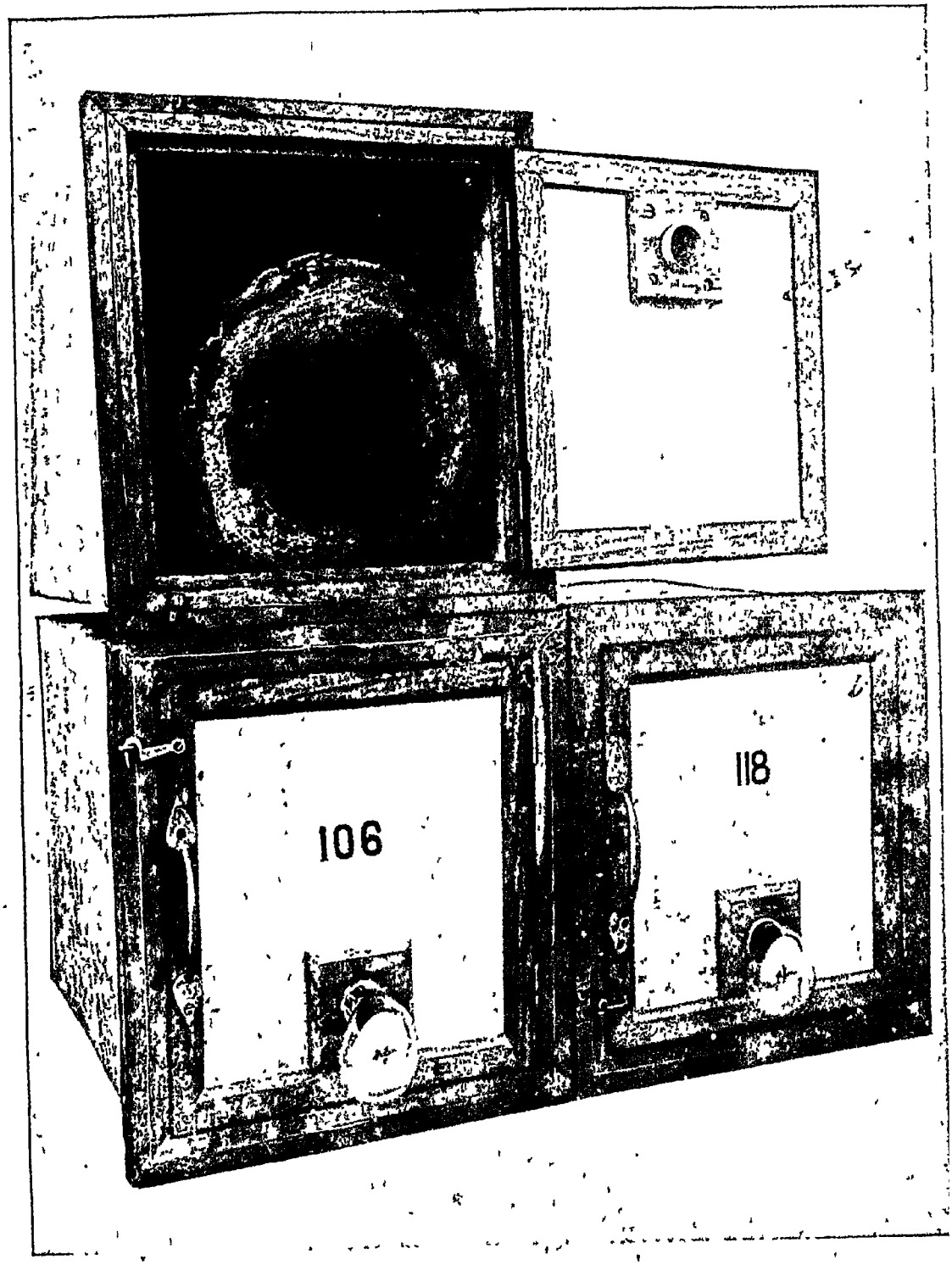


Photo.-Mech. Dept., Thomason College, Roorkee.

Galvanized iron cages in which the air and wood humidity can be regulated.

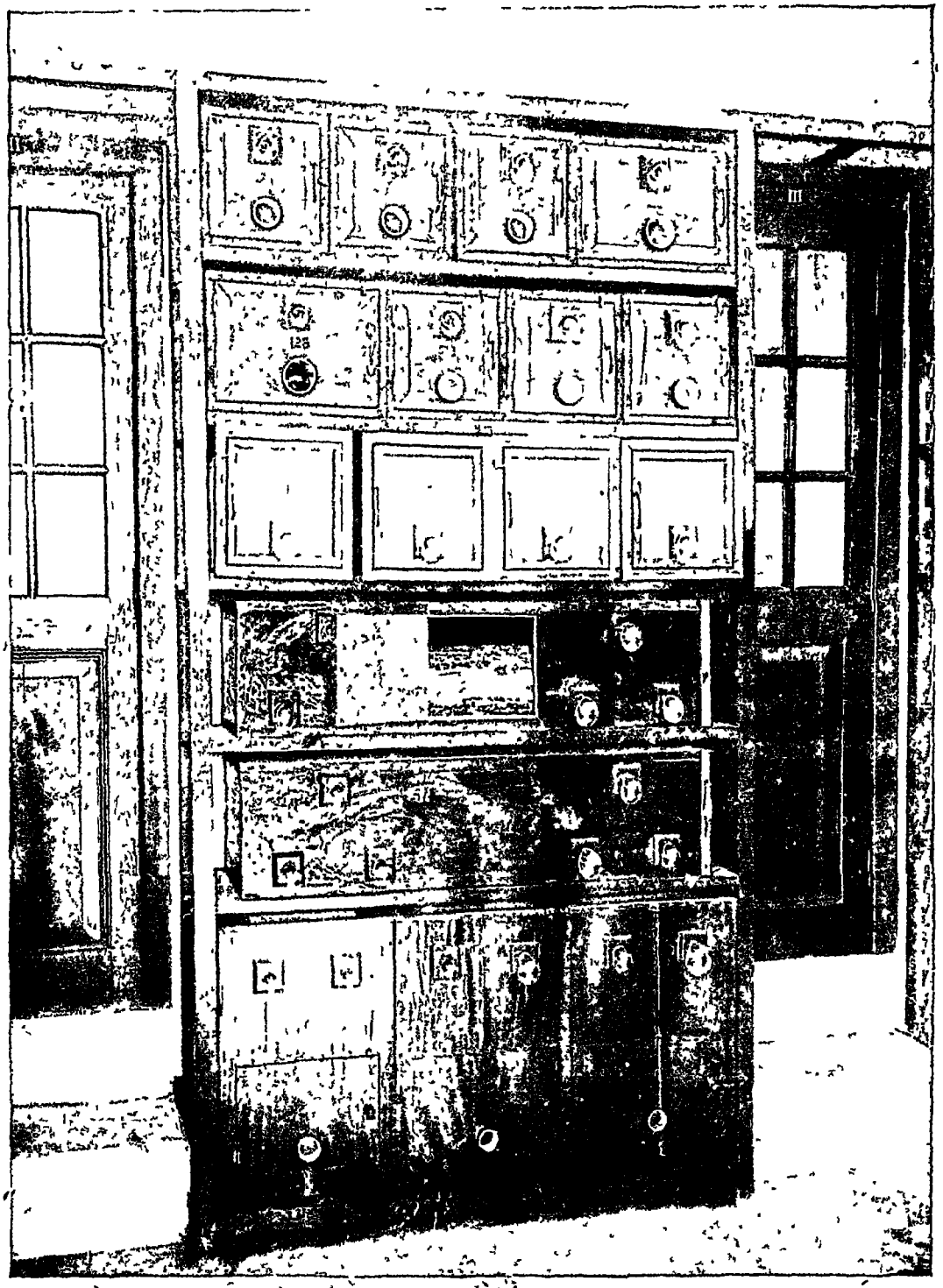


Photo.-Mech. Dept., Thomason College, Roorkee.

Types of breeding cages used for wood-borers in the Forest Zoologist's Insectary.

The compilation of the food-plants of forest insects has been continued with the issue of the families Platypodidæ and Scarabœidæ.

The more important of the new records are:—

Platypus solidus, Wlk.	ex *Litsea polyantha; Pterospermum acerifolium;*
Xystrocera globosa, Olv.	ex *Albizzia stipulata;*
Xyleborus perforans, Woll.	ex *Litsea polyantha;*
Calopepla leayana, Latt.	ex *Gmelina arborea;*
Clania variegata, Snell.	ex *Casuarina equisetifolia;*
Stromatium barbatum, Fabr.	ex *Alnus nepalensis; Sterculia alata; Quercus lanuginosa; Q. serrata; Garcinia indica; Dalbergia Sissoo.*
Rhynchophorus ferrugineus, Olv.	ex *Oreodoxa regia;*
Oryctes rhinoceros, Linn.	ex *Cocos nucifera;*
Xyleborus sp.	ex *Xylia dolabriformis;*
Phlococinus jubatus,	ex *Abies Webbiana;*
Heterobostrychus aequalis, Waterh.	ex *Dipterocarpus turbinatus;*
Epania sp.	ex *Calophyllum Wightianum;*
Xylotrechus sp.	ex *Dalbergia Sissoo; Odina Wodier;*
Xylodectes ornatus, Lesne.	ex *Bauhinia Vahlii;*
Aphrodisium cantori, Hope.	ex *Mallotus philippinensis;*
Xylotrechus smei, C. & G.	ex *Kydia calycina;*
Phassus, signifer, Wlk.	ex *Tectona grandis;*
Gelonaetha hirta, Fairm.	ex *Heritiera Fomes;*
Platypus uncinatus, Bldf.	ex ,, ,,
Belinota prasina, Themb.	ex *Sonneratia apetala;*
Xylothrips flavipes, Ill.	ex *Vateria indica; Odina Wodier;*
Olenocaniptus bilobus, Fabr.	ex *Ficus religiosa;*
Glenia multigutiata, Gahan,	ex *Shorea robusta;*
Sthenias grisator, F.	ex *Morus alba;*
Poritia hewettsoni,	ex *Dipterocarpus pilosus;*
Xylocopa latipes, Fabr.	ex *Amoora Wallichii;*
Adoretus sp.	ex *Bombax malabaricum;*
Cerococcus hibisci, Gr.	ex *Premna latifolia; Anogeissus latifolia;*
Dactylopius sp.	
Eriococcus sp.	ex *Mangifera indica;*
Ceroplates sp.	
Ceresium zeylanicum, Whit.	ex *Careya arborea;*
Arbella tetraonis, Mo.	ex *Anogeissus latifolia;*

Museum.—The principal additions include 243 specimens of timber, injurious insects, skins and shikar trophies, some of the latter loaned by Sir George Hart.

Records.—Card indices to the collections, pests of forest trees and current literature are up to date, but the interpretation and collation of insectary records and field-observations has not made relative progress. There are about 15 subjects on various aspects of forest entomology for which material is available for publications, but the pressure of current work postpones the possibility of writing-up the data in Record or Bulletin form. As soon as the posts of forest entomologist are filled it is hoped that there will be opportunities for publishing these data.

Staff.—Messrs. D. Atkinson and J. C. M. Gardner who have been selected for appointment to two of the posts of forest entomologist will complete their training in forestry and entomology at the close of 1921. It is proposed to appoint Mr. Mackenzie, I.F.S., to a third post of forest entomologist to investigate the beehole borer in Burma.

In February 1921, the Forest Zoologist and Systematic Entomologist attended the 4th Entomological meeting held at Pusa. Papers were read by the former on the Imperial Entomological Conference in London, 1920, and on the progress of research in forest entomology.

Publications.—The following issued after the close of the year:—

(1) Beehole Borer of Teak (*Duomitus ceramicus*, Wlk.) by C. F. C. Beeson.

(2) Lac and Shellac by H. A. F. Lindsay and C. M. Harlow.

(3) The Food Plants of Indian Forest Insects, part vi (family Scarabaeidæ) by C. F. C. Beeson. (*Indian Forester*, June 1921.)

Library.—One hundred new books in addition to periodicals were added.

Systematic Entomology.—The post of Systematic Entomologist has been filled by the appointment of Surgeon Commander M. Cameron, M.B., R.N., on the 4th December 1920.

The material awaiting classification and identification amounts to tens of thousands of specimens of insects and their early stages. Considerable progress has been made in the naming-up of monographed groups of Coleoptera by Dr. Cameron and in the distribution of material to specialists in other orders. In collaboration with Colonel Winn-Sampson, the Forest Zoologist has been working on the revision of the Indian Platypodidæ and Scolytidæ necessitated by the re-determination of Stebbing's types. Some 350 species new to the Research Institute collection have been added during the period under review. The following specialists are

engaged in the identification of forest insects (*D.* indicates the despatch and *R.* the receipt of material during the year):—

Dr. G. Arrow, *Lamellicornia, Endomychidæ, Erotylidæ* (D. R.); Mr. H. E. Andrews, *Carabidæ* (D. R.), *Adephaga* (R.); Mr. K. G. Blair, *Tenebrionidæ* (D. R.); Mr. E. Brunetti, *Diptera* (D. R.); Mr. J. Corporaal, *Cleridæ* (D.); Mr. St. J. Donisthorpe, *Formicidæ* (D.); Mr. T. B. Fletcher, *Odonta, Pyralidæ* (D.); Major Fraser, *Odonata* (D. R.); M. P. Lesne, *Bostrychidæ* (D. R.); Dr. G. A. K. Marshall, *Curculionidæ* (D. R.); Dr. E. Meyrick, *Microlepidoptera* (D. R.); Miss. G. Ricardo, *Asilidæ* (D. R.); Mr. Wasman, *Termitophila* (D.); Government Entomologist, Madras, *Apidæ* (R.).

The following families have been revised and expanded, but the permanent arrangement of the collection awaits the provision of suitable store-cabinets:—

Coleoptera; Staphylinidæ, Scarabæidæ Curculionidæ, Chrysomelidæ; Hymenoptera; Fossores; Lepidoptera; Lymantriidæ, Notodontidæ.

Burma.

Little progress can be made in this subject until a special officer is appointed.

No result can be reported on the trial of nest boxes in plantations in Prome and Tharrawaddy. Unfortunately in Tharrawaddy Division young villagers are reported to have found some of the boxes first and the birds did not get a chance. Nevertheless birds did nest in a few of the boxes but were not seen by anyone with sufficient knowledge of ornithology to identify them. Results however cannot be expected immediately and it will require careful study over a number of years by an expert to record any definite results.

Mr. Forster reports that early burning of the reserves in the West Salween Division did not seem to effect the teak leaf defoliator in any way.

Larvæ of the following insects were found tunnelling in the stems of 3-year old teak trees in Thaungyin Division:—

1. *Phassus signifer* (*Hepialidæ*).
2. *Haplohammus cervinus* (*Lœmiidæ*).
3. *Sagra* sp.? (*Chrysomelidæ*).
4. Unknown *Lepidoptera*.

A new species of shot hole borer, *Xyleborus* sp., *Scolytidæ* was reported from North Pegu Division. It was found attacking some felled Pyinkado in the Aingdonkun Reserve. It was identified by the Forest Zoologist, Dehra Dun, who remarks:—"The borer is

new to the collection and no previous record of this insect or its attack on Pyinkado has been made."

Bombay.

Teak Pests.—Many of the 1919 teak plants in the Nisalnir and Taltot plantations S. D. Kanara Division were found to be damaged by the stem borer about the month of August. The insect has girdled the plants in many cases about a foot from the ground. The parts thus attacked appear to heal up soon by occlusion. In order to ascertain this 100 plants in each of the plantations have been marked and are under observation.

The same plantations $1\frac{1}{2}$-year old were attacked by defoliators in September and October last. All the leaves macerated and fell by October. There was new foliage, a sort of epicormic growth by November; but this again dropped down in February. The plants are now looking like sticks except for the dormant terminal buds. This may be due to the defoliation.

Teak seed collected in 1919 when there was a general attack by the teak defoliator proved to be very poor in germinating powers.

CHAPTER VI.

Forest Chemistry.

Central Institute.

The following is a list of the subjects sanctioned for investigation in the Chemical Branch of the Forest Research Institute during the period under report:—

1. *Gums, Resins, Oleo-resins and Essential Oils.*—
 (1) General study of essential oils.
2. *Miscellaneous Enquiries.*—
 (1) Chemistry of Indian turpentines.
3. *General investigation into the nature and value of dyes obtainable from woods, barks, fruits, flowers and leaves.*

Essential Oils.—Experiments on Indian turpentine from *Pinus longifolia* have been continued during the year. The work has been mainly concerned (*a*) with the synthesis of the new bicyclic terpene *d—carene* and (*b*) with efforts to find some economic use for *d—longifolene.*

The experiments on the synthesis of *d—carene* are still in the preliminary stage and are not sufficiently advanced to determine whether they will be successful.

d—longifolene is in all probability a tricyclic sesquiterpene and in view of the frequent occurrence of sesquiterpenes in essential oils

it appears desirable to endeavour to find some use for them. At present they only find a small market as fixatives and turpentine substitutes. Up to the present owing to the great stability of longifolene all experiments have been negative but it is hoped that satisfactory results will be obtained when more light has been thrown on the constitution of longifolene. Experiments in this direction have been planned and will be commenced as soon as the necessary apparatus has been installed.

Some experiments were made on the standardisation of turpentine using the refractive index of the oil as a guide to its purity. These experiments showed promise and it is hoped that arrangements will be made either at Jallo or Bareilly for a complete investigation. A simple method of standardisation would be of great value in the factories.

Essential Oil from *Skimmia Laureola*.—The examination of this oil (from the leaves) has been completed and a paper on the subject is in the press. The oil consists of *d—linalyl acetate* (approximately 50 per cent.), *d—linalol*, a trace of terpene (possibly terpinene) and a mixture of sesquiterpenes and sesquiterpene alcohols. A sample of the oil is being valued.

Essential Oil from *Zanthoxylum alatum*.—The examination of this oil (from the seeds) is also complete. It has been found to contain *d—linalol* (approximately 50 per cent.), phellandrene dipentene and methyl cinnamate. There appears to be some reason to doubt whether the seeds were obtained from *Z. alatum* or *Z. acanthopodium* and this point will be definitely settled this year. At the same time it is proposed to investigate the essential oils derived from other species of Zanthoxylums. The oil from *Z. alatum* is being valued in England.

Essential Oil from *Blumea Malcolmii*.—It had been hoped to arrange for the distillation of this grass in Belgaum but owing to the difficulty of obtaining a certificated boilerman the trip had to be abandoned. Two parcels of leaves were distilled at Dehra Dun but the yield of oil was very small.

Deodar Wood Oil.—The oil from *Cedrus Deodara* has been distilled from the saw dust of some logs supplied by the Silviculturist. The yield of oil is about 2·7 per cent. and its composition agrees with that found for previous samples of the oil examined at the Imperial Institute (See Roberts, Journ. Chem. Soc. (1916), 791). This oil is being valued in England.

Camphor.—The results of the chemical investigation of the camphor leaf oil from leaves grown in Dehra Dun have been published during the year. (Journ. Soc. Chem. Ind. 1920, *39*, 296T). In collaboration with the officer-in-charge, Minor Forest Products, and the Silviculturist the acreage yield and the prospects of establishing the camphor industry in India are being examined. The

laboratory work has shown that the oil from the leaves is of little value apart from its camphor content since safrol is absent.

Fixed Oils.—The oils from the seeds of *Garcinia Morella*, *Garcinia Cambogia* and *Mimusops Elengi* have been under investigation during the past year. The first two are fats and should apparently be of considerable value if they can be obtained in sufficient quantity. Further experiments on these three oils are in progress.

The oil from several samples of olive seeds grown near Rawalpindi was expressed at the request of the Forest Economist. The yield of oil was low but the oil obtained was of good quality.

A small sample of *Payena oleifera* oil was sent by the Forest Economist for examination. It was too small in quantity for any experiments of value to be made.

Vegetable Dyestuffs.—Work on the synthesis of morindone, the colouring matter present in *Morinda citrifolia* and *Morinda umbellata* has been continued. The experiments are approaching completion and do not lend themselves to summarisation.

A quantity of rottlerin has been extracted from the seeds of *Mallotus philippinensis*. Owing to the readiness with which it is attacked by reagents the determination of its constitution is likely to be a matter of considerable difficulty.

Medicinal Plant Products.—As the result of a careful analysis of a large number of samples of the flower heads of *Artemisia maritima*, gathered weekly during the growing season under the direction of the Conservator of Forests, Kashmir, Santonin has been found to be present in workable quantity. This discovery is one of considerable importance as Santonin is at the present time practically unobtainable and has the fancy price of £50 per kilo. The question of the commercial extraction of Santonin in Kashmir is now being considered.

Miscellaneous.—A very large number of moisture determinations in timber have been made for the Forest Economist. This work has taken up a large portion of the time of one of the assistants.

A sample of creosote oil was analysed and passed as suitable for use for creosoting timber. Subsequently the Government Test House, Calcutta, rejected a sample from the bulk. This rejection was shown to be unwarranted and was due to a wrong method of analysis having been adopted. A working standard for the analysis of creosotes based on American practice has been drawn up and approved by the Forest Economist.

The juice and the fruits of Cactus received from Jodhpur were shown not to contain a dyestuff of any value. The colour is probably due to the presence of an insoluble anthocyanin dye.

A number of other analyses for Forest Officers were made, and an article on the distillation of camphor in India was published in the Journ. Soc. Chem. Ind. (1920, *39*, 296T.).

A note is given of various other researches on Forest Products which have been made in India.

Fowler and Joshi (Journ. Ind., Inst. of Sc., Vol. 3, page 39) have studied the fermentation of cellulose. They consider that it should be possible under certain conditions to generate power gas (methane) by the fermentation of waste cellulose materials which are frequently available in quantity as for example on the West Coast.

Sudborough and Vridhachalam (Journ. Ind., Inst. of Sc., Vol. 3, page 61) have investigated the extraction of tartaric acid from tamarinds. They show that the acid is readily recovered and are of opinion that it should be a paying industry. (Results of a similar nature were communicated to the Indian Munitions Board by Dr. B. B. Dey of Calcutta during the war. These results have not been published.)

Fowler, Behram, Bhate, Hassan, Mahdihassan and Inuganti (Journ. Ind., Inst. of Sc., Vol. 3, page 81) have published a lengthy study of the bio-chemistry of the Mahua Flower. The results do not lend themselves to summarisation.

Sudborough and Watson with several collaborators (Jour. Ind., Inst. of Sc., Vol. 3, page 281) have published Part III of their researches on wood distillation. This Part of the research is concerned mainly with the distillation of certain Mysore and Baroda woods under conditions similar to those used in previous experiments. The results are given in a number of tables. They have also investigated the distillation of cocoanut shells and have confirmed the high acetic acid yield. The tar from the shells is of interest since it contains on appreciable quantity (6·2 per cent.) of ordinary phenol.

Fowler and Malandkar (Journ. Ind., Inst. of Sc., Vol. 4, page 27) have published details of their method for the separation of the turpentine, rosin and gum from the gum-oleo-resin from *Boswellia serrata*. The method advocated does not involve extraction with a solvent which was the basis of Pearson and Puran Singh's method of separation and should be much cheaper to work.

CHAPTER VIII.

Forest Publications.

The necessity for an organised publication branch grows more apparent each year. Not only are scientific results being obtained

which to be useful must be made public at once, but it is obvious that in future the Department must consider the spreading of information concerning its work an integral part of its acitivity. A great deal of the prejudice which at present exists against the Department is due largely to ignorance of its work and its aims, and it must under the new conditions be part of the work of the Department to remove this ignorance.

A beginning has been made in this direction by having descriptive articles published in several of the newspapers showing what work is being carried on, but it is hoped that next year's report will certain a record of considerable progress in this direction.

The United Provinces are to be congratulated on having also made a beginning on similar lines.

The following publications were either issued during the year or were in the press at its close:—

Serial No.	Title.	Author.	Date of issue.
	FOREST RECORDS.		
	Issued.		
1	Note on the Afforestation of Ravine Lands in the Etawah District, United Provinces.	E. A. Smythies.	December 1920.
	In Press.		
2	Note on the Beehole Borer of Teak	C. F. C. Beeson	(Issued in December 1921).
3	Report on Lac and Shellac	H. A. F. Lindsay and C. M. Harlow	(Issued in May 1921).
4	Note on the Regeneration of Sal Forests	R. S. Hole	(Issued in July 1921).
5	Notes on Artificial Regeneration in Bengal.	E. O. Shebbeare, A. K. Glasson, L. E. S. Teague and P. T. Russell.	(In final print.)
	FOREST BULLETINS.		
	Issued.		
6	Note on Pyinma, Ajhar or Jarul Wood (*Lagerstroemia Flos-Reginæ*, Retz.)	R. S. Pearson	August 1920.
	In Press.		
7	Note on Weights of Seeds	S. H. Howard	(Issued in April 1921).
8	Note on *Adina cordifolia*	C. E. C. Cox	(Issued in September 1921.)
9	Note on *Odina Wodier*	,,	Do.
10	Note on *Bombax malabaricum*	,,	Do.
11	Note on Rate of Growth of Bengal Sal	S. H. Howard	Do.
12	Note on the Miscellaneous Forests of the Kumaon Bhabar.	E. A. Smythies	Do.
	OTHER PUBLICATIONS.		
	Issued.		
13	Forest Research Institute and College, Calendar, 1919.	...	October 1920.
14	Progress Report of Forest Research Work in India for 1919-20.	...	January 1921.
15	Progress Report of the Forest College, Dehra Dun, for 1919-20.	...	Do.
	In Press.		
16	Code for the Collection and Tabulation of Statistical Data.	S. H. Howard	(Issued in July 1921.)
17	Do. Do. Appendices	Do.	Do.

The following publication is being issued by the Central Institute for the Conservator of Forests, Bengal :—

Nursery Notes for Bengal.

UNITED PROVINCES.

Issued.

1. Enumeration of miscellaneous species of the Haldwani Division.
2. Felling scheme of *Acacia Catechu* of the Haldwani-Ramnagar Bhabar.

In Press.

3. Afforestation in the United Provinces, by E. Benskin, I.F.S., (Issued in August 1921).

BURMA.

Issued.

1. A Handbook of the Forest Products of Burma, by A. Rodger.

In Press.

2. Bulletin No. 1.—Preparation of Teak seed for early germination, by H. R. Blanford, O.B.E., I.F.S.
3. Bulletin No. 2.—Early burning in Young Regeneration Areas, by C. G. E. Dawkins, I.F.S. (Issued in August 1921).
4. Bulletin No. 3.—Teak Stumps, by U. Po. Thin, K.S.M., A.T.M., Extra Assistant Conservator of Forests, Katha Division.

APPENDIX I.

Administration Report of the Forest Research Institute, Dehra Dun, for the year 1920-21 (1st July 1920 to 31st March 1921).

Administration.—The post of President, Forest Research Institute and College, was held by Mr. R. C. Milward, Officiating Chief Conservator of Forests, from 1st July to 16th November 1920, and for the rest of the year by the writer of the report (except for the period 17th to 27th November 1920 when Mr. J. E. Macpherson, Personal Assistant to the President, held charge of the current duties of the President's Office).

The names of the officers who held charge of the various branches are given below :—

Branch of Forest Research Institute.	Month and Date.		Name of Officer-in-Charge of branch.
	From	To	
Silviculture	1st July 1920.	31st March 1921	Mr. S. H. Howard, B.A., Deputy Conservator of Forests, United Provinces.
Forest Botany	1st July 1920	28th December 1920.	Do.
	29th December 1920.	31st March 1921	Mr. R. S. Hole, C.I.E., F.C.H., F.L.S., F.E.S., *Conservator of Forests.*
Forest Economy	1st July 1920	3rd July 1920	Mr. C. E. C. Cox, Deputy Conservator of Forests, Central Provinces.
	4th July 1920	26th August 1920.	Mr. R. C. Milward, Officiating President, Forest Research Institute and College.
	27th August 1920.	31st March 1921	Mr. R. S. Pearson, C.I.E., F.L.S., Officiating Conservator of Forests, Bombay Presidency.
Forest Zoology	1st July 1920	8th July 1920	Mr. F. M. Howlett, M.A., Imperial Pathological Entomologist, Pusa.
	9th July 1920	31st March 1921	Mr. C. F. C. Beeson, M.A., I.F.S., F.E.S., Deputy Conservator of Forests, Punjab.
Forest Chemistry	1st July 1920	18th September 1920.	Dr. J. L. Simonsen, D.Sc., F.I.C., F.A.S.B.
	19th September 1920.	24th January 1921.	Mr. C. F. C. Beeson, M.A., I.F.S., F.E.S., Deputy Conservator of Forests, Punjab.
	25th January 1921.	20th March 1921.	Mr. M. Gopal Rao, M.A., Assistant to Forest Chemist.
	21st March 1921.	31st March 1921.	Dr. J. L. Simonsen, D.Sc., F.I.C., F.A.S.B.

APPENDIX II.

Financial.

The expenditure of the past two years is compared below :—

——	Expenditure during the year.		Difference or
	1919-20 (12 months July 1919 to June 1920).	1920-21 (9 months July 1920 to March 1921).	
AVI Stores, Tools and Plant . . .	8,328	26,906	+18,578
AVII Buildings, etc.	3,820	2,852	— 968
AIX Miscellaneous	35,972	31,526	— 4,446
BI*a* Conservators	18,996	15,641	— 3,355
BI*b* Superior Officers	58,866	99,245	+40,379
BIc Subordinate Forest and Depôt Establishment.	12,736	3,379	— 9,357
BI*d* Office Establishment	32,518	34,081	+ 1,563
BIe Deputation and Special Allowances .	9,524	13,246	+ 3,722
BI*f* Compensation for dearness of provisions	1,606	995	— 611
BII Travelling Allowances	16,558	19,087	+ 2,529
BIII Contingencies	17,346	25,038	+ 7,692
Total .	2,16,270	2,71,996	+55,726

The increase under AVI is due to the purchase of machinery for the Economic Branch consequent on its expansion.

The decrease under AVII is due to less expenditure having been incurred on repairs during the year.

The decrease under AIX is due to less expenditure having been incurred on experiments.

The decrease under BI*a* is due to the figures for 1920-21 representing 9 months against 12 months for 1919-20.

The increase under BI*b* is due to the appointment of Experts in the Economic branch and to the pay of Assistants Upper Grade charged under this head.

The decrease under BIc is due to the pay of Upper Grade Assistants having been charged under BI*b* owing to the raising of their status.

The increase under BI*d* is due to the entertainment of extra establishment in the Economic branch and to the re-organization of clerical, miscellaneouts and menial establishment having been brought into force with effect from the 1st October 1920.

The increase under BI*e* is due to the Upper Grade Assistants to Research Institute Officers having been allowed to draw a duty allowance of Rs. 75 per mensem each under the new scheme.

The decrease under BI*f* is due to the abolition of compensation for dearness of provisions with effect from 1st October 1920.

The increase under BII is due to extensive touring done by certain Research Institute Officers.

The increase under BIII is due to more expenditure having been incurred on the carriage of tents and records on tours by Research Officers and to the purchase of books and periodicals for the Forest Chemist.

APPENDIX III.

Annual Form No. 24.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISIONS.

Summary of Revenue of the different Divisions during 1920-21.

BUDGET HEADS. (1)	President. (2)	Sylviculturist. (3)	Forest Botanist. (4)	Forest Zoologist. (5)	Forest Economist (6)	Forest Chemist. (7)	TOTAL. (8)
REVENUE.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
I—TIMBER AND OTHER PRODUCE REMOVED FROM THE FOREST BY GOVERNMENT AGENCY—							
(a) Timber . .	..	..	..	..	..	..	..
(b) Firewood and charcoal.	..	..	..	..	..	..	..
(c) Bamboos .	..	..	..	..	..	..	..
(d) Sandal-wood .	..	..	..	..	..	..	..
(e) Grass and other minor produce	..	..	..	..	..	..	..
TOTAL I .	..	..	..	..	..	..	..
II.—TIMBER AND OTHER PRODUCE REMOVED FROM THE FORESTS BY CONSUMERS OR PURCHASERS—							
(a) Timber . .	..	..	..	..	..	..	..
(b) Firewood and charcoal.	..	..	..	..	..	..	..
(c) Bamboos .	..	..	..	..	..	..	..
(d) Grazing and fodder grass	..	..	..	..	..	..	..
(e) Other minor produce	..	..	..	..	..	..	..
(f) Other items .	..	..	..	..	..	..	..
(g) Commutation fees	..	..	..	..	..	..	..
TOTAL II .	..	..	..	..	..	..	..
III.—DRIFT AND WAIF WOOD AND CONFISCATED FOREST PRODUCE.							
TOTAL III .	..	..	..	..	..	..	..
IV.—REVENUE FROM FORESTS NOT MANAGED BY GOVERNMENT—							
(a) Duty on foreign timber and other forests produce.	..	..	..	..	..	..	..
(b) Revenue from shared and private forests	..	..	..	..	..	..	..
TOTAL IV .	..	..	..	..	..	..	..
V.—MISCELLANEOUS—							
(a) Fines and forfeitures	..	..	..	..	..	..	..
(b) Refunds .	54 1 0	..	..	57 1 4	9 11 8	..	121 1 0
Other sources .	6,238 5 2	70 8 0	80 15 0	0 13 4	126 9 0	61 13 6	6,608 0 0
TOTAL V .	6,312 6 2	70 8 0	80 15 0	58 1 8	136 1 8	61 13 6	6,720 1 0
GRAND TOTAL REVENUE.	6,312 6 2	70 8 0	80 15 0	58 1 8	136 1 8	61 13 6	6,720 1 0

APPENDIX III—*contd.*

Annual Form No. 24—*contd.*

Summary of Revenue of the different Divisions during 1920-21.

Budget Heads. (1)	President. (2)	Sylviculturists (3)	Forest Botanist. (4)	Forest Zoologist. (5)	Forest Economist. (6)	Forest Chemist. (7)	Total. (8)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
EXPENDITURE.							
A.—Conservancy and Works.							
I.—Timber and other produce removed from the forests by Government Agency—							
(*a*) Timber . .	..	..	..	..	..	..	..
(*b*) Firewood and charcoal	..	..	..	..	..	..	..
(*c*) Bamboos .	..	..	..	..	..	..	..
(*d*) Sandal-wood .	..	..	..	..	..	..	..
(*e*) Grass and other minor produce.	..	..	..	..	..	..	..
Total A. I .	..	..	..	..	..	..	..
II.—Timber and other produce removed from the forest by consumers or purchasers—							
Total A. II.	..	..	..	..	..	..	..
III.—Drift and waif wood and confiscated forest produce—							
Total A. III .	..	..	..	..	..	..	..
IV.—Revenue from forests not managed by Government—							
(*a*) Duty on foreign timber and other forest produce.	..	..	..	..	..	..	..
(*b*) Revenue from shared and private forests	..	..	..	..	..	..	..
Total A. IV .	..	..	..	..	..	..	..
V.—Rent of leased forests and payments to shareholders in forests managed by Government—							
Total A. V. .	..	..	..	..	..	..	..

APPENDIX III—*contd.*

Annual Form No. 24—*contd.*

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISIONS.

Summary of Expenditure of the different Divisions during 1920-21.

BUDGET HEADS.	President.	Sylviculturist.	Forest Botanist.	Forest Zoologist.	Forest Economist.	Forest Chemist.	TOTAL.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
VI.—LIVE-STOCK, STORES, TOOLS AND PLANT—							
(a) Purchase of cattle	..	..	..	..	..	..	..
(b) Feed and keep of cattle.	..	..	..	..	..	..	..
(c) Purchase of stores, tools and plant.	21,302 2 0	57 0 0	37 0 0	2,068 8 0	1,014 2 0	1,327 8 0	26,006 4 0
TOTAL A. VI .	21,302 2 0	57 0 0	37 0 0	2,068 8 0	1,014 2 0	1,327 8 0	26,006 4 0
VII.—COMMUNICATIONS AND BUILDINGS—							
(a) Roads and bridges.	..	..	..	..	..	..	..
(b) Buildings .	2,212 12 7	14 0 0	..	..	..	..	2,226 12 7
(c) Other works .	610 14 3	3 4 0	..	2 8 0	..	..	625 10 3
TOTAL A. VII .	2,832 10 10	17 4 0	..	2 8 0	..	..	2,852 6 10
VIII.—ORGANIZATION, IMPROVEMENT AND EXTENSION OF FORESTS—							
(a) Demarcation .	..	..	..	..	..	..	..
(b) Cost of Forest Settlements; compensation for land and rights.	..	..	..	..	..	..	..
(c) Surveys . .	..	..	..	..	..	..	..
(d) Working plans	..	..	..	..	..	..	..
(e) Sowing and planting	..	..	..	..	..	..	..
(f) Protection from fire.	..	..	..	..	..	..	..
(g) Other Works .	..	..	..	..	..	..	..
TOTAL A. VIII .	..	..	..	..	..	..	..
IX.—MISCELLANEOUS							
(a) Law charges .	..	..	..	..	..	..	..
(c) Other charges .	13,617 14 10	2,228 14 6	814 0 6	1,147 6 11	8,687 7 1	4,830 0 2	31,525 12 3
TOTAL A. IX .	13,617 14 10	2,228 14 6	814 0 6	1,147 6 11	8,687 7 1	4,830 0 2	31,525 12 3
TOTAL A.—CONSERVANCY AND WORKS.	37,052 11 8	2,303 2 6	851 0 6	3,218 6 11	9,701 9 1	6,357 8 2	61,284 7 1
B.—ESTABLISHMENTS.							
I.—SALARIES—							
(a) Conservators .	12,129 10 6	..	3,511 4 8	..	..	..	15,640 15 2
(b) Superior Officers	6,300 0 0	10,408 5 4	4,101 4 7	15,431 12 3	54,254 2 9	8,750 3 11	99,244 12 10
(c) Subordinate forest and depôt establishments.	..	1,100 0 0	378 8 0	1,300 0 0	..	600 0 0	3,378 8 0
(d) Office establishments.	7,260 1 9	3,861 11 11	4,012 4 10	5,700 6 10	10,274 15 6	2,951 15 1	34,081 7 11

APPENDIX III—*concld.*

Annual Form No. 24—*concld.*

Summary of Expenditure of the different Divisions during 1920-21—concld.

Budget Heads. (1)	President. (2)	Sylviculturist. (3)	Forest Botanist. (4)	Forest Zoologist. (5)	Forest Economist. (6)	Forest Chemist. (7)	Total. (8)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
II.—ESTABLISHMENT—*contd.*							
SALARIES—*contd.*							
(e) Deputation and special allowances.	916 10 8	2,250 0 0	2,500 10 10	2,670 15 4	4,229 15 2	668 11 4	13,245 15 4
(f) Grain compensation allowance.	307 0 0	120 10 11	171 8 2	240 15 11	87 7 9	58 3 2	994 13 11
TOTAL B. I. .	26,033 6 11	17,749 12 2	15,071 9 1	23,314 2 4	68,846 9 2	12,038 1 6	1,66,586 9 2
II.—TRAVELLING ALLOWANCES—							
(a) Conservators .	222 5 6	..	330 13 0	..	..	..	550 2 6
(b) Superior Officers	232 3 0	3,223 11 6	502 2 6	1,083 4 0	7,030 6 3	415 10 6	14,287 5 9
(c) Subordinate forest and depôt establishments	..	155 5 4	12 0 0	..	..	..	167 5 4
(d) Office establishments.	144 15 10	812 1 11	151 2 3	520 11 1	2,363 0 1	60 5 2	4,072 13 4
TOTAL B. II. .	599 8 4	4,221 2 9	1,002 1 9	2,603 15 1	10,203 15 4	405 15 8	19,080 10 11
III.—CONTINGENCIES							
(a) Stationery .	4 2 0	18 1 0	39 12 0	71 0 0	13 14 0	10 1 0	157 7 0
(b) Carriage of tents and records	..	715 0 2	1 8 0	85 7 0	1,502 2 1	..	2,304 1 3
(c) Rents, rates and taxes	1,500 7 1	..	60 0 0	..	..	..	1,560 7 1
(d) Pay of police guards	..	..	..	..	..	..	..
(e) Official postage	303 1 0	94 1 6	240 3 6	101 6 0	368 12 6	150 10 0	1,348 2 6
(f) Sundries and Telephone charges.	6,828 8 10	430 15 6	868 8 2	1,208 8 2	8,653 11 5	1,617 8 4	19,607 12 5
Compensation for dearness of provisions.	..	..	..	..	..	..	..
TOTAL B. III .	8,636 2 11	1,258 2 2	1,209 13 8	1,566 14 2	10,598 8 0	1,778 3 4	25,037 14 3
TOTAL B.—ESTABLISHMENT.	36,169 2 2	23,229 1 1	17,286 10 6	29,484 15 7	89,739 0 6	14,882 4 6	2,10,711 2 4
GRAND TOTAL OF EXPENDITURE.	74,121 13 10	25,532 3 7	18,137 11 0	33,523 6 6	99,440 0 10	21,230 12 8	2,71,905 0 5
SURPLUS OR DEFICITS	—67,899 7 8	—25,455 11 7	—18,056 11 3	—33,465 1 10	—99,304 5 2	—21,174 15 2	—2,65,266 7 8

CALCUTTA,
The 16th September, 1920-21.

M. N. GUPTA,
Assistant Accounts Officer.

Certified that the totals of this form as printed in Forest College and Forest Research Institute Reports for 1920-21 when added together agree with those entered in the forms for the combined offices as supplied by the Accountant General, Central Revenues, under Article 78 (*ii*) of the Forest Department Code.

W. F. PERREE,
President, Forest Research Institute and College.

APPENDIX

Form No. 25

FOREST DEPARTMENT, INDIA,

Account current for

RECEIPTS.

——	President.	Sylviculturist.	Botanist.	Zoologist.	Economist.	Forest Chemist.	TOTAL.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
CASH BALANCE .	..	..	..	..	..	..	..
VIII.—ASSIGNED TAXES—							
Income Tax—deductions from salaries	..	509 5 0	379 7 0	547 0 9	2,545 8 3	317 9 7	4,278 14 7
REVENUE DURING THE YEAR.	6,312 0 1	76 8 0	80 15 9	58 1 8	136 4 8	61 13 6	6,729 1 8
FOREST DEPOSITS .	..	..	..	..	..	..	..
FOREST ADVANCES .	..	12,572 1 5	3,076 15 11	3,236 2 7	7,067 0 6	3,624 11 3	29,573 8 5
SUSPENSE ACCOUNT .	..	..	..	..	..	..	..
SERVICE FUNDS—							
Uncovenanted Service Family Pension Fund, Bengal	..	..	3 1 3	..	..	..	3 1 3
SAVINGS BANK DEPOSITS—							
Bank Account—							
Miscellaneous, Provident Fund.	..	..	..	250 0 0	..	..	250 0 0
General Provident Fund.	..	2,012 0 9	717 2 7	1,536 0 0	1,657 3 10	191 5 1	6,113 11 9
Special Account—							
General Family Pension Fund.	..	..	..	..	..	..	..
House building advances	..	..	..	202 8 0	..	..	202 8 0
Motor car advances	..	1,777 10 8	40 0 0	83 3 4	1,308 10 0	..	3,199 10 0
Objection book advances	..	..	..	..	300 0 0	..	300 0 0
CASH REMITTANCES—LOCAL—FOREST REMITTANCES.							
Forest cheques drawn.	11,035 11 3	..	201 8 9	2,011 1 9	..	1,223 2 10	14,531 11 7
Revenue Remittances written back.	..	..	..	20 0 0	..	..	20 0 0
Inter-divisional Transfers.	..	..	..	..	..	..	..
ACCOUNT CURRENT WITH FOREIGN STATES							
His Majesty's Colonial Government, Ceylon.	..	..	..	..	..	..	..
Carried over .	17,348 1 4	16,947 9 1	4,559 0 3	7,931 7 1	13,201 4 3	5,421 10 6	65,835 6 6

IV.

—[*Prescribed.*]

FOREST RESEARCH INSTITUTE, FOREST DIVISION.

the Forest year 1920-21.

PAYMENTS.

—	President.	Sylviculturist.	Botanist.	Zoologist.	Economist.	Forest Chemist.	TOTAL.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
I.—REFUNDS AND DRAWBACKS.							
EXPENDITURE DURING THE YEAR.	74,121 13 10	25,532 3 7	18,137 11 0	33,523 6 6	99,140 9 10	21,239 12 8	2,71,995 9 5
FOREST DEPOSITS	..	..	..	..	..	..	..
FOREST ADVANCES	..	13,368 6 5	4,333 9 6	3,768 8 7	10,299 14 9	3,595 1 3	34,065 8 6
House building advances . .	..	..	..	..	..	320 0 0	320 0 0
SUSPENSE ACCOUNT SAVINGS BANK DEPOSITS	..	..	..	..	..	..	..
Motor Car Advances	..	..	..	3,000 0 0	11,800 0 0	..	14,800 0 0
Objection book advances.	..	..	450 0 0	..	1,050 0 0	..	1,500 0 0
Bank account—							
General Provident Fund.	..	1,000 0 0	149 11 4	..	..	..	1,149 11 4
Forest Officers' Provident Fund.	..	..	..	..	..	..	..
CASH REMITTANCES —LOCAL—FOREST REMITTANCES.							
Remittances to Treasuries	..	..	..	..	..	..	..
Unpaid cheques written back.	..	..	..	..	..	..	..
Inter-divisional Transfers.	..	..	..	..	..	..	..
ACCOUNT CURRENT WITH FOREIGN STATES							
His Majesty's Colonial Government, London.	..	..	55 0 0	..	..	..	55 0 0
EXCHANGE ACCOUNT WITH OTHER GOVERNMENTS—							
Account between India and Central Provinces—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
Carried over .	74,121 13 10	39,900 10 0	23,126 8 10	30,291 15 1	1,22,290 8 7	25,154 13 11	3,24,786 0 3

APPENDIX

Form No. 25

FOREST DEPARTMENT, INDIA,

Account current for

RECEIPTS.

——	President.	Sylviculturist.	Botanist.	Zoologist.	Economist.	Forest Chemist.	TOTAL.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A.
Brought forward .	17,348 1 4	16,047 0 1	4,389 6 3	7,031 7 1	13,291 4 3	5,724 10 6	63,835 0 6
EXCHANGE ACCOUNT WITH OTHER GOVERNMENTS—							
Account between India and Central Provinces—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Central Provinces.	..	..	..	..	140 0 0	..	140 0 0
Account between India and Burma—							
III.—Items adjustable by India.	..	..	..	..	3,290 15 7	..	3,290 15 7
IV.—Items adjustable by Burma.	..	..	..	..	4,750 5 4	..	4,750 5 4
Account between India and Behar and Orissa—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Behar and Orissa.	..	..	50 0 0	..	..	..	50 0 0
Account between India and Bengal—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Bengal.	..	..	..	..	373 3 6	..	373 3 6
Account between India and United Provinces of Agra and Oudh—							
III.—Items adjustable by India.	61,379 1 7	23,815 2 11	18,019 12 10	29,063 11 2	69,716 14 1	19,154 10 6	2,22,031 8 1
IV.—Items adjustable by United Provinces.	..	..	..	..	..	..	..
Account between India and Assam—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
Carried over .	78,727 5 11	40,762 12 0	22,459 0 1	37,093 2 3	91,562 10 9	24,879 5 0	2,96,524 13 0

IV.—(*contd.*)

—[*Prescribed.*]

FOREST RESEARCH INSTITUTE, FOREST DIVISION.

the Forest year 1920-21.

PAYMENTS.

—	President.	Sylviculturist.	Botanist.	Zoologist.	Economist.	Forest Chemist.	TOTAL.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Brought forward .	74,121 13 10	39,900 10 0	23,126 8 10	39,891 15 1	1,22,590 8 7	25,154 13 11	3,24,786 0 3
IV.—Items adjustable by Central Provinces.	..	..	..	..	355 10 3	..	355 10 1
Account between India and Burma—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Burma.	..	..	..	..	..	..	..
Account between India and Assam—							
II.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Assam.	..	..	..	..	..	..	..
Account between India and Bengal—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Bengal.	..	..	..	..	..	..	..
Account between India and United Provinces of Agra and Oudh—							
III.—Items adjustable by India.	6,312 0 1	76 8 0	..	78 1 8	126 9 0	62 15 6	6,656 8 3
IV.—Items adjustable by United Provinces.	..	1,000 0 0	..	..	..	..	1,000 0 0
Account between India and Punjab—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Punjab.	..	..	..	..	..	..	..
Account between India and Madras—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Madras.	..	..	..	..	..	..	..
Carried over .	80,434 3 11	40,977 2 0	23,126 8 10	39,970 0 0	1,23,072 11 10	25,217 13 5	3,32,798 8 7

APPENDIX

Form No. 25

FOREST DEPARTMENT, INDIA,

Account current for

RECEIPTS.

——	President	Sylviculturist	Botanist.	Zoologist.	Economist.	Forest Chemist.	TOTAL.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Brought forward .	78,727 5 11	40,702 12 0	22,050 9 1	37,903 2 3	91,502 10 9	21,870 5 0	2,90,524 13 0
IV.—Items adjustable by Assam.	..	..	..	..	..	..	..
Account between India and Madras—							
III —Items adjustable by India.	..	..	..	..	..	..	..
IV —Items adjustable by Madras.	..	..	..	..	..	..	..
Account between India and Bombay—							
III.—Items adjustable by India.	..	..	145 1 5	..	79 14 7	..	225 0 0
IV.—Items adjustable by Bombay.	..	..	25 3 0	..	..	..	25 3 0
INTER-DEPARTMENTAL TRANSFERS—							
P. W. Department, Ordinary Branches.	..	..	..	..	..	..	..
P. W. Department, Railway Branch.	..	..	..	..	..	..	..
Military Department, Supply Circle.	..	..	..	..	..	..	..
Military Department, Western Command.	..	..	..	..	1,125 3 6	..	1,125 3 6
Military Department, Account between India and N. W. Railway.	..	..	..	..	..	..	..
Military Department, Secunderabad Division.	..	..	..	..	..	..	..
Telegraph Department.	..	..	..	..	..	..	..
Post Office Department Miscellaneous (War Loan).	..	..	..	..	..	..	..
Post Office Department P. I. Fund.	..	..	13 2 0	67 0 6	..	..	80 2 6
Marine Department .	..	..	..	..	..	..	..
Account with N.-W. Railway.	..	..	..	..	..	..	..
Civil Departments .	1,700 14 0	214 6 0	284 11 4	1,999 14 0	30,541 2 8	338 8 5	35,085 8 5
GRAND TOTAL .	80,431 3 11	40,977 2 0	23,127 10 10	39,970 0 9	1,23,338 15 0	25,217 13 5	3,33,065 14 5

IV—*concld.*

—[*Prescribed.*]

FOREST RESEARCH INSTITUTE, FOREST DIVISION.

the Forest year 1920-21.

PAYMENTS.

—	President.	Sylviculturist.	Botanist.	Zoologist.	Economist.	Forest Chemist.	TOTAL.
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
Brought forward .	80,434 3 11	40,077 2 0	23,126 8 10	39,970 0 9	1,23,072 11 8	25,217 13 5	3,32,798 8 7
Account between India and Bombay—							
III.—Items adjustable by India.	..	..	..	..	..	..	..
IV.—Items adjustable by Bombay.	..	..	..	..	..	..	..
INTER-DEPARTMENTAL TRANSFERS—							
Public Works Department, Ordinary Branches.	..	..	..	..	..	..	..
Public Works Department, Railway Branch	..	..	..	..	..	..	..
Military Supply Department.	..	..	..	..	..	..	..
Military Department, Northern Command.	..	..	..	..	..	..	..
Military Department, Western Command.	..	..	..	..	..	..	..
Military Department, Secunderabad Division.	..	..	..	..	..	..	..
Telegraph Department.	..	..	..	..	..	..	..
Post Office Department.	..	..	..	..	..	..	..
Marine Department.	..	..	..	..	..	..	..
Civil Departments.	..	..	1 2 0	..	206 3 10	..	207 5 10
Account between India and North Western Railway.							
III—Items adjustable by India.	..	..	..	..	..	..	..
CASH BALANCE .	..	..	..	..	..	..	..
GRAND TOTAL .	80,434 3 11	40,077 2 0	23,127 10 10	39,970 0 9	1,23,338 15 6	25,217 13 5	3,33,005 14 5

CALCUTTA,
The 16th September 1921.

M. N. GUPTA,
Assistant Accounts Officer.

Certified that the totals of this form as printed in the Forest College and Forest Research Institute Reports for 1920-21 when added together agree with those entered in the forms for the combined office as supplied by the Accountant General, Central Revenues, under Article 78 (*ii*) of the Forest Department Code.

W. F. PERREE,
President, Forest Research Institute and College

APPENDIX V.

Annual Form No. 27.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE.

Outstandings and Liabilities on account of Contractors and Disbursers for the Forest year 1920-21.

Divisions.	DEPARTMENT DEBTOR.			DEPARTMENT CREDITOR.			BALANCE DUE.		REMARKS.
	Opening balance.	Recoveries in Cash and value of supplies and work done during the year.	Total.	Opening balance.	Payments made during year.	Total.	To Department (Outstandings).	By Department (Liabilities).	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
Sylviculturist	..	12,572 1 5	12,572 1 5	190 2 9	13,368 6 5	13,558 9 2	986 7 9	..	
Forest Botanist	..	3,076 15 11	3,076 15 11	151 7 11	4,333 9 6	4,485 1 5	1,408 1 6	..	
Forest Zoologist	..	3,236 2 7	3,236 2 7	221 14 1	3,368 8 7	3,590 6 8	354 4 1	..	
Forest Economist.	..	7,063 9 6	7,063 9 6	196 14 10	10,299 14 9	10,496 13 7	3,433 4 1	..	
Forest Chemist	..	3,624 11 3	3,624 11 3	120 12 8	3,595 1 3	3,715 13 11	91 2 8	..	
TOTAL .	..	29,573 8 8	29,573 8 8	881 4 3	34,965 8 6	35,846 12 9	6,273 4 1	..	

M. N. GUPTA,
Assistant Accounts Officer.

CALCUTTA,
The 16th September 1921.

Certified that the totals of this form as printed in the Forest College and Forest Research Institute reports for 1920-21 when added together agree with those entered in the Forms for the combined offices as supplied by the Accountant General, Central Revenues, under Article 78 (*ii*) of the Forest Dpartment Code.

W. F. PERREE,
President, Forest Research Institute and College.

APPENDIX VI.

List of Forest Publications issued since the creation of the Forest Research Institute.

I.—Bulletins (Old Series).

	Price (exclusive of packing, postage, etc.). Rs. a. p.
1.—Note on the Bee-hole Borer of Teak in Burma, by E. P. Stebbing. (*Out of print*)	0 4 0
2. Note on the Quetta Borer (*Æolesthes sarta*), by the same author. (*Out of print*)	0 8 0
3.—Note on the Chilgoza (*Pinus Gerardiana*) Bark-Boring Beetles of Zhob, Baluchistan, by the same author. (*Out of print*)	0 8 0
4.—*Pinus elastica*: its natural growth and artificial propagation, with a description of the method of tapping the tree and of the preparation of its rubber for the market, by E. M. Coventry	0 12 0
5.—Notes on a Visit to some European Schools of Forestry, by E. P. Stebbing. (*Out of print*)	2 0 0
6.—Memorandum on Mechanical Tests of some Indian Timbers, by W. H. Everett	0 2 0
7.—Note on the Chilgoza Forests of Zhob and the Takht-i-Sulaiman, by E. P. Stebbing. (*Out of print*)	0 12 0
8.—Note on the Life-History of *Hoplocerambyx spinicornis* (The Singbhum Sal Borer), by the same author	0 9 0
9.—Note on the influence of Forests on the Storage and Regulation of the Water-Supply, by S. Eardley-Wilmot	1 0 0
10.—Note on the Duki Fig-Tree Borer of Baluchistan (*Batocera rubus*), by E. P. Stebbing. (*Out of print*)	0 7 0
11.—On Some Assam Sal (*Shorea robusta*) Insect Pests, by the same author	1 10 0

II.—Leaflets.

1.—The Sal Bark-Borer (*Sphærotrypes siwalikensis*, Stob.), by E. P. Stebbing. (*Out of print*)	0 4 0
2.—The Teak Defoliator (*Hyblæa puera*, Cram.), by the same author. (*Out of print*)	0 2 0
3.—The Teak Leaf Skeletoniser (*Pyrausta machæralis*, Wlk.), by the same author. (*Out of print*)	0 2 0
4.—The Larger Deodar Bark-Borer (*Scolytus major*, Stob.), by the same author. (*Out of print*)	0 4 0
5.—The Blue Pine "Polygraphus" Bark-Borer (*Polygraphus major*, Stob.), by the same author. (*Out of print*)	0 3 0

III.—Pamphlets.

1.—Note on Utilization of Khair Forests in Eastern Bengal and Assam, by Puran Singh. (*Out of print*)	0 4 0
2.—The Attack of the Bark-Boring Beetle in the Coniferous Forests in the Simla Catchment Area, by E. P. Stebbing	0 8 0
3.—A Glossary of Forest Technical Terms for Use in Indian Forestry, by A. M. F. Caccia. (*Revised and issued as Bulletin No. 4, New Series*). (*Out of print*)	0 4 0
4.—Note on Lac and Lac Cultivation, by D. N. Avasia	0 2 0
5.—Notes on Sal in Bengal, by A. L. McIntire. (*Out of print*)	0 4 0
6.—Note on Forest Reservation in Burma in the Interests of an Endangered Water-Supply by A. Rodger	1 0 0
7.—Note on Andaman Marble Wood or Zebra Wood (*Diospyros Kurzii*, Hiern.), by R. S. Troup	0 4 0
8.—Note on the Collection of Statistical Data relating to the principal Indian Species, by A. M. F. Caccia	0 10 0
9.—Tables showing the Progress in Working-Plans in the Provinces outside the Madras and Bombay Presidencies up to 31st December 1908, by the same author	0 10 0

	Price (exclusive of packing, postage, etc.). Rs. a. p.
10.—Note on Burmese Leza Wood (*Lagerstræmia tomentosa*, Presl.), by R. S. Troup	0 2 0
11.—Note on Carallia Wood (*Carallia integerrima*, DC.), by the same author	0 2 6
12.—Note on Petwun or Trincomali Wood (*Berrya Ammonilla*, Roxb.), by the same author	0 4 0
13.—Note on Burmese In Wood (*Dipterocarpus tuberculatus*, Roxb.), by the same author	1 0 0
14.—Note on Burma Padouk (*Pterocarpus macrocarpus*, Kurz.), by the same author	1 0 0
15.—Note on the Preservation of Bamboos from the Attacks of the Bamboo Beetle or "Shot-Borer," by E. P. Stebbing	0 7 0
16.—Note on the Best Season for Coppice Fellings of Teak (*Tectona grandis*), by R. S. Hole	0 1 0
IV.—Bulletins (New Series).	
1.—Note on Calorimetric Tests of Some Indian Woods, by Puran Singh	0 2 0
2.—Memorandum on Teak Plantations in Burma, by F. A. Leete	0 10 0
3.—Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by R. S. Pearson	0 4 0
4.—Second Edition of the Glossary of Technical Terms for Use in Indian Forestry, by A. M. F. Caccia, revised by R. S. Troup	0 6 0
5.—The Blue Pine Tomicus Bark-Borer (*Tomicus Ribbentroppi*), by E. P. Stebbing	0 2 0
6.—Memorandum on the Oil-Value of Sandalwood, by Puran Singh	0 2 0
7.—Note on the Chemistry and Trade Forms of Lac, by the same author	0 3 0
8.—Note on some Germination Tests with Sal Seed (*Shorea robusta*), by R. S. Troup	0 2 0
9.—Note on Resin-Value of *Podophyllum Emodi* and the best season for collecting it, by Puran Singh	0 1 3
10.—Note on the Bark-Boring Beetle Attack in the Coniferous Forests of the Simla Catchment Area, 1907—1911, by R. S. Hole	0 3 0
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12.—Note on the Bark-Eating and Root-Boring Beetles of Babul (*Acacia arabica*), by E. P. Stebbing	0 4 0
13.—Note on *Ligno Protector* as a possible means of preventing timber from splitting while seasoning, by R. S. Pearson	0 5 0
14.—A Further Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by the same author	0 3 0
15.—Note on the Technical Properties of Timber with special reference to *Cedrela Toona* wood while seasoning, by the same author	0 3 0
16.—Note on Gumhar (*Gmelina arborea*, Roxb.), by A. Rodger	0 3 0
17.—Note on Bija Sal or Vengai (*Pterocarpus Marsupium*, Roxb.), by the same author	0 4 0
18.—Note on Sain or Saj (*Terminalia tomentosa*, W. and A.), by the same author	0 5 0
19.—Note on Benteak or Nana Wood (*Lagerstræmia lanceolata*, Wall.), by the same author	0 3 0
20.—Note on Sandan (*Ougeinia dalbergioides*, Benth.), by the same author	0 3 0
21.—Note on Dhaura Bakli (*Anogeissus latifolia*, Wall.), by the same author	0 4 0
22.—Note on the Causes and Effects of the Drought of 1907 and 1908 on the Sal Forests of the United Provinces, by R. S. Troup	0 5 0
23.—Note on the Preparation of Indian Forest Floras and Descriptive Lists, by R. S. Hole	0 4 0
24.—Note on Turpentines of *Pinus Khasya*, *Pinus Merkusii* and *Pinus excelsa*, by Puran Singh	0 2 0
25.—Development of the Culms of Grasses, by R. S. Hole	0 2 0
26.—Note on the Resin Industry in Kumaun, by E. A. Smythies	1 4 0
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28.—Note on Dhauri (*Lagerstræmia parviflora*, Roxb.), by the same author	0 4 0
29.—Note on Sundri Timber (*Heritiera minor*, Lam.), by R. S. Pearson	0 3 0
30.—The Compilation of Girth Increments from Sample Plot Measurements, by R. S. Troup	0 2 0

	Price (exclusive of packing, postage, etc.). Rs. a. p.
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„ „ 3. A Note on the Present Position and Future Prospects of the Cutch Trade in Burma, by R. S. Troup	
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